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GENERAL ELECTRIC REVIEW

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the more power to america Special

September, 1950

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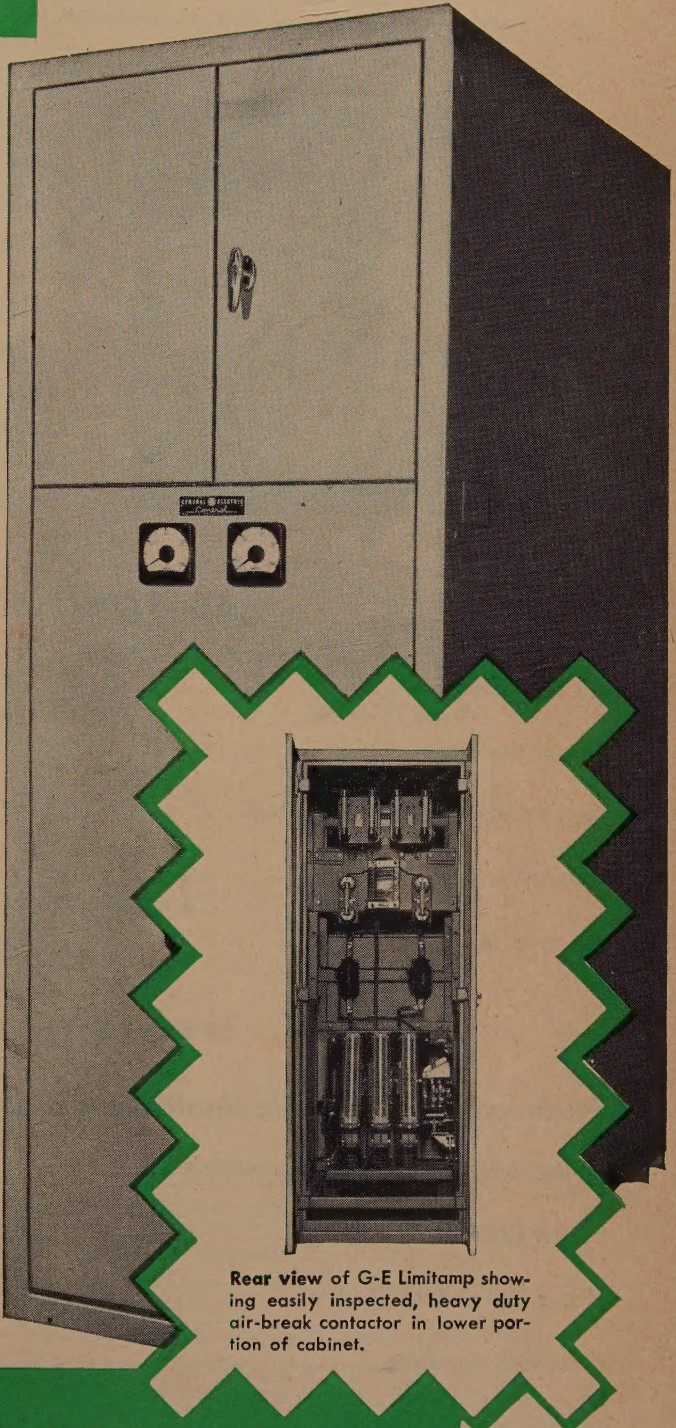

Rear view of G-E Limitamp showing easily inspected, heavy duty air-break contactor in lower portion of cabinet.

GENERAL ELECTRIC

730-17

GENERAL ELECTRIC Review

SEPTEMBER 1950
Vol. 53 Number 9

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THE COVER

The picture of the More Power to America Special which appears on the cover of this special issue of the REVIEW was painted by Howard Fogg, who is rapidly becoming one of the foremost railroading artists of this generation. Now official artist of the American Locomotive Company, he has exhibited his collection of railroad paintings in a number of American cities.

A railroad hobbyist since childhood, Mr. Fogg is a graduate of Dartmouth College and the Chicago Academy of Fine Arts. During World War II he flew 76 combat missions as a fighter pilot in the European Theatre. His studio is in Basking Ridge, New Jersey.

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CIRCULATION DEPT: General Electric Review, Schenectady 5, N. Y.

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CHANGE OF ADDRESS: Give old and new addresses. Notices received before the fifteenth of the month will be effective with the next issue.

Entered as second-class matter, March 26, 1912, at the post office at Schenectady, N. Y., under Act of March 3, 1879. Published monthly by General Electric Company, 1 River Road, Schenectady 5, N. Y. Printed in U.S.A. *Copyright 1950 by General Electric Company.*

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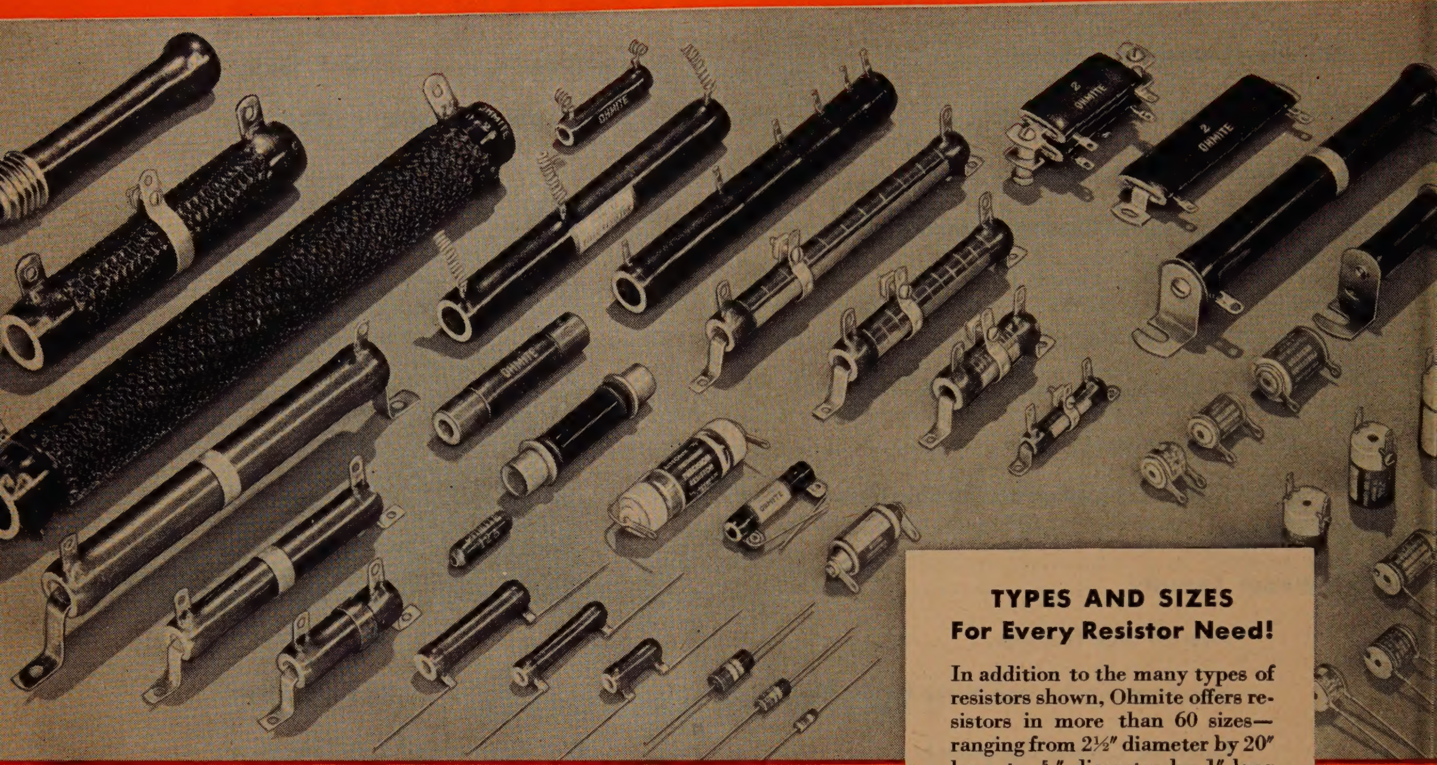

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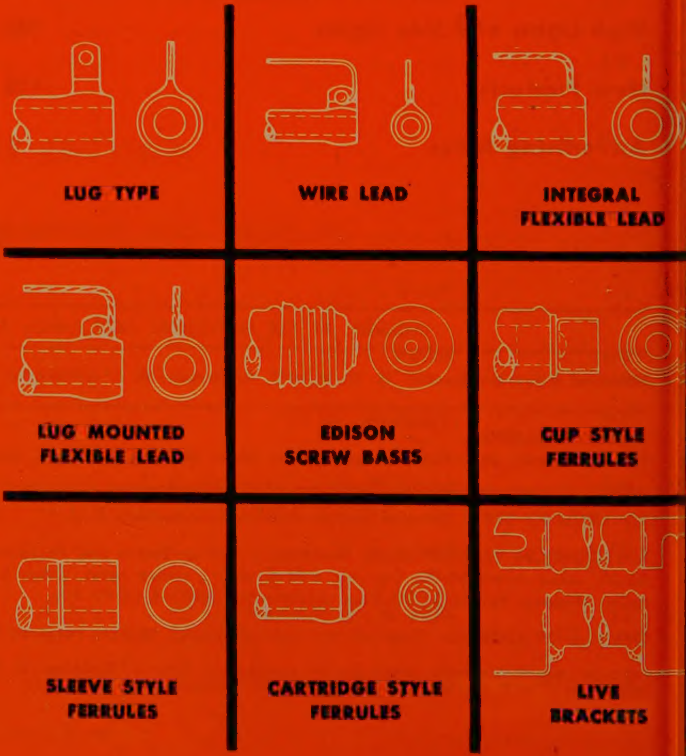

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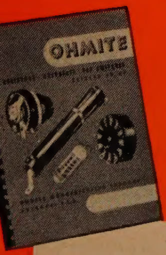

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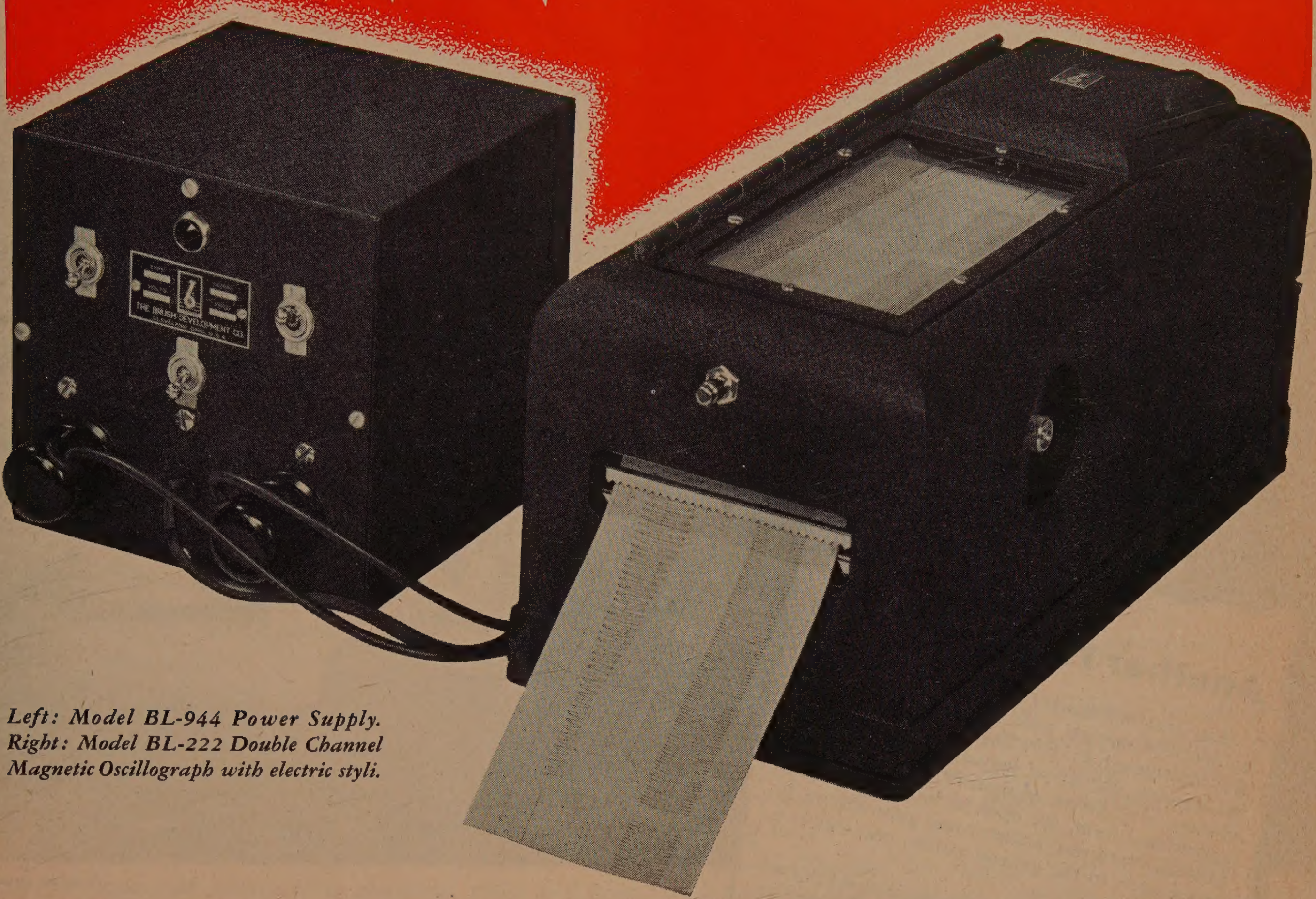

Left: Model BL-944 Power Supply.
Right: Model BL-222 Double Channel Magnetic Oscillograph with electric styli.

New BRUSH Combination Oscillograph has interchangeable electric stylus and inking pen

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The Model BL-944 Power Supply, shown above on the left, has a switch on the front panel to increase stylus voltage for recording high frequency phenomena.

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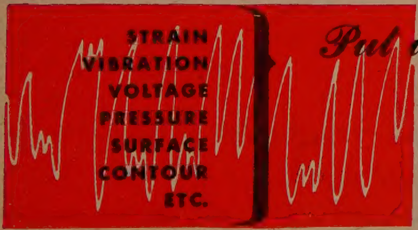

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Photo by George Bur

Another Freedom Train

The General Electric Company's "More Power to America" special train is down at the North Station through Friday. The ten cars, filled with an amazing display of industrial electrical machinery and power equipment, much of it in operational form, are open to invited representatives of business, industry and government. It is not open to the general public, and this is a pity.

A visitor to the special can see it as simply an assembly of devices that make for efficiency in industry. Or he can see the marvelous ingenuity of electrical engineers and enjoy the delight of supreme gadgetry.

Or he can see behind the exhibit something as symbolic of American freedom as the Declaration of Independence and the Constitution and the other historic documents of the Freedom Train. These jet turbines, these automatic power distribution systems, these atomic and ultrasonic testers, these complex drives, these diesel-electric controls, are the creation of a free enterprise system. They were designed, built and integrated into production in response to demands freely expressed by free consumers bidding with free dollars for what they want.

Nothing but a big business, a large aggregation of capital, could accomplish this so effectively and efficiently. It could not be done half so well by a lot of small companies nor by government operation under the direction of a set of bureaucrats. The competition of a multitude of technical and business minds went into the production of these devices. The best and most practical methods and devices survived. No government planners could match this process.

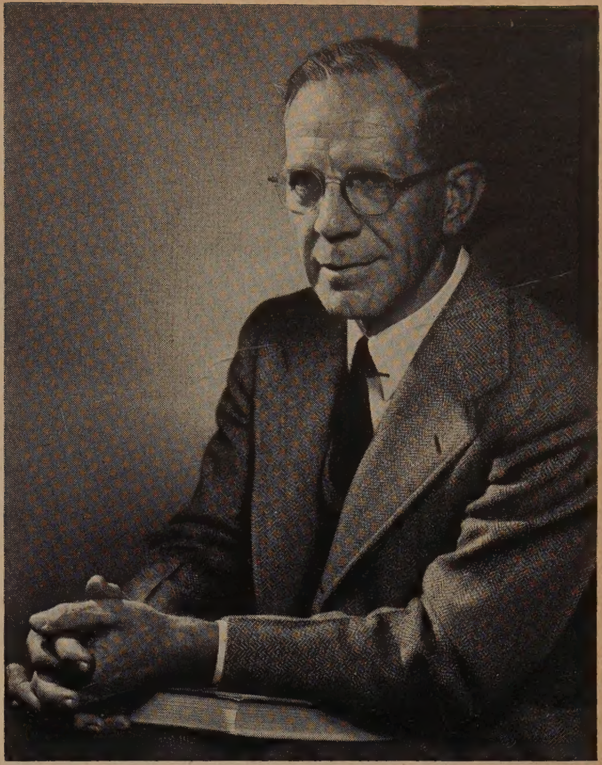
. . . And that is why this is in its way another freedom train, and why it should be seen by all Americans.

From an editorial in

THE
BOSTON HERALD
WEDNESDAY, MAY 24, 1950

the WHY
OF THE TRAIN

By C. H. LANG
Vice President and Manager of Marketing
Apparatus Department
General Electric Company



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IT'S a curious thing, but very few of the 33,000 people who have seen the More Power to America Special thus far have asked us why it was built.

When you actually see this titanic electrical fair on wheels, it seems perfectly obvious that it will have a very stimulating effect, not only on General Electric business, but on the nation as a whole.

Practically all of our visitors have remarked on the terrific impact of seeing 2000 electrical ideas and products, all jam-packed into one inspiring tour of the train. A good many of these ideas are spectacular in themselves. When they are all brought together, they give an impressive indication of how great their collective contribution can be to a more productive America, at peace or at war.

And yet, since this *is* a unique undertaking in industrial marketing, and since it was obviously a very expensive project, it seems that something more ought to be said about the reasons that prompted General Electric to create, build, and launch the More Power to America Special.

First of all, of course, the train was designed to promote the sale of G.E.'s apparatus products to industry, transportation, power suppliers, municipal authorities, government, and the military.

As a business-builder for General Electric, the exhibit train will fully justify the time and expense involved in making it and bringing it to 150 of the nation's leading industrial centers.

INVESTMENT IN PROSPERITY AND SECURITY

But there was more than this simple commercial motive behind the MPA Special. *Fundamentally, this train is an investment in the continuing prosperity and security of the United States.*

To some of the critics of free competitive enterprise, it seems impossible that a business corporation could have such lofty motives; but actually, motives of this kind are very much in the thinking of the business community today.

General Electric, for example, with its 250,000 stockholders, 180,000 employees, 200,000 dealers, as well as 31,000 suppliers, all have a vital stake in the prosperity and security of this country. It is just common sense—as well as good citizenship—to make every possible contribution, within our sphere of action, to the general well-being of the nation.

Our sphere of action is the *electrification* and *modernization* of industry. In many respects, these words are synonymous. As industry has given the workman more electrically powered machinery, he has become more productive.

Back in 1900, it is estimated that the average American workman used electricity at the rate of 0.1 kilowatt-hour per man-hour. Today, the national average is 6.2 kilowatt-hours per man-hour. The effects of this on worker productivity are apparent to everyone—and especially to the worker, who works a shorter work week, and yet has tremendously increased his purchasing power.

Look at it another way: America has doubled her use of electricity every eleven years since the turn of the century. Electric utilities have doubled and redoubled their capacity in order to stay ahead of the requirements.

Such progress is not merely a matter of happenstance. It has come about because industry has constantly made investments in new electrified machinery, to increase productivity and cut costs. It has come about because electric utilities have had the courage to expand their systems, in advance of need, in order to be ready for the next era of progress.

ELECTRIFICATION MUST BE STEPPED UP

Yes, America has been electrifying at an incredible rate. But as the nation grows—as its world responsibilities increase—that rate of electrification must be stepped up.

Civic and industrial leaders must be persuaded to make the capital investments needed to keep our cities and industries ahead of the ever-present threat of obsolescence.

It has been said that Britain won world leadership because she knew how to build her industries; and she lost leadership because she did not know how to *rebuild* them. This is a fate we must avoid.

By such bold and perhaps unorthodox means as the More Power to America Special, as well as the rest of General Electric's More Power to America programs, we can help to keep industry abreast of the times. We can encourage the continuing capital investment in new machines, new electrical processes, which can keep our industry always modern—always efficient.

There are compelling reasons for this all-out war on obsolescence. To the businessman, it becomes increasingly clear that cost-reduction through more efficient machinery is the only escape from the inflationary pressures of rising labor and material costs. Unless industry can find more economical ways to produce its goods—there's going to be a bad squeeze on profits and, with it, a weakening of our capital structure.

The housewife is interested, too. She'll go where she can get goods at lowest prices. The manufacturer with the modern, efficient plant will get her business. If obsolescence pushes costs out of line in too many plants, business will simply slow down—and so will employment.

This is reason enough to keep pushing the fight on obsolescence. But America today has perhaps an even more urgent reason to keep her industry in fighting trim: *the explosive international situation.*

PRODUCTIVITY AND NATIONAL SECURITY

America's strength—which today undergirds the strength of the free world—lies in her industrial productivity. The armed millions of Communism far outnumber the standing armies of the free world. But America—6% of the world's population producing over 33% of the world's output—can tilt the scales again on the side of freedom, in case of "partial" or total war.

In the past decade we learned what it is to serve as "the arsenal of democracy." In those areas where our productive equipment was obsolete, we had difficulty in meeting the fantastic requirements of world war. Fortunately, we had time for a long running start on our production job.

This time (as the Korean outbreak indicates) if war should come, we may well *begin in the thick of it.*

Here is the most compelling argument for keeping our industrial and municipal equipment in fighting trim. Here is the best reason for keeping America's business and governmental leaders fully informed on the latest developments that will speed production and cut costs.

Of course, the More Power to America Special cannot show nearly all the latest developments, even of General Electric. In the past ten years, our laboratories and engineering offices have produced about 8000 inventions—roughly two a day, year in and year out. In addition, we produce literally thousands of other ideas for product improvement and combination, far too numerous to patent, but each adding to the sum of human knowledge.

Just to show a limited representation of these ideas, we are sending across the country a display kit nine feet wide and a quarter-mile long. And to haul it to your town, we've turned to the only transportation agency in the world capable of handling such an assignment: the American railroads. Here are steel tracks, a well-established network of paths to all the industrial centers to be reached. In passing, we might note that the More Power to America Special is General Electric's vote of confidence in the future of American railroads. The exhibit train is not simply a verbal endorsement of railroad transportation; it is an investment and a physical demonstration.

To railroads and other transportation agencies . . .
To electric power suppliers . . .
To producers of raw materials and finished goods . . .
To businessmen and municipal authorities . . .
To military and governmental leaders . . .
. . . the train brings a powerful and dramatic demonstration of electrical ideas that can add immeasurably to our national prosperity and security.

The editorial on the frontispiece, which appeared in *The Boston Herald*, calls the train "Another Freedom Train." It says things that catch the spirit of the train—and things that General Electric could not modestly say itself.

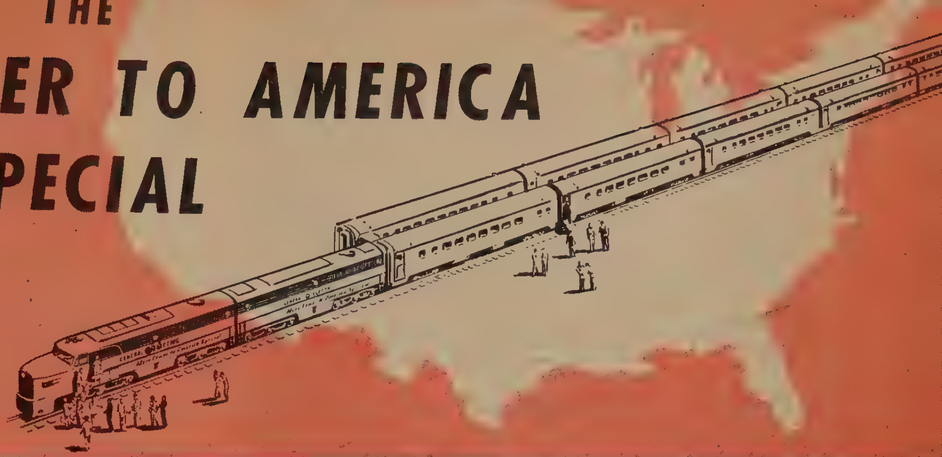
CREATION OF WEALTH

There has been much emphasis, in the past two decades, on the *distribution* of wealth. An important objective. But perhaps in our pursuit of fair distribution we have lost sight of a more important objective: the *creation* of wealth. That may be because the group which is most directly concerned with producing our national wealth, the American business community, has failed to assert itself clearly enough.

Here is the vital mission of businessmen at mid-century: we must again turn the minds of the American people to the *creation* of wealth, to the *modernization* of our industrial machine, to the building of a more *productive* America.

Freedom, security, and productivity are all inextricably bound together. We cannot have one without the others. And that is the proposition to which the More Power to America Special is dedicated.

THE MORE POWER TO AMERICA SPECIAL



By C. P. FISHER, Jr.
Advertising and Sales Promotion Divisions,
Apparatus Department
General Electric Company

THE More Power to America Special displays more than 2000 products and ideas for creating electric power and putting it to effective use throughout industry, in community improvement projects, and in the interests of national defense.

The Special is a ten-car, silver streamliner hauled by a new, bright-red, Alco-GE locomotive. Its itinerary takes it to some 150 United States industrial centers during 1950 and 1951 for inspection by invited representatives of electric power suppliers and manufacturing and transportation industries, by civic leaders and the military. Designed specifically as a travelling showcase of electric apparatus, systems, and techniques for plant improvement, machinery modernization, and national welfare, the train is not open to the public.

Planning and developing the More Power to America Special presented a variety of unusual problems requiring the knowledge and skills of many. Probably no pioneer bride of the 70's starting for the open West by covered wagon allotted her space in the Conestoga more frugally than the staff on design and layout of the train.

The building of either a railroad car or a roving exhibit presents a mass of individual problems. But making allowances for the exhibits in building the cars and designing the same exhibits for installation and operation within the cars introduces an entirely new set of considerations.

J. S. Smith (left), manager of G-E Apparatus Advertising and Sales Promotion Divisions, congratulates C. P. Fisher, Jr., whose group was responsible for production of the MPA Special.

For example:

—Structure of the railroad car must provide adequate securing points for heavy exhibits.

—Weight of exhibits must be limited and equally distributed throughout the car to avoid unbalance.

—Size and shape of the exhibits is governed by door frame and interior car dimensions.

—Location of exhibits must be carefully planned for comfortable inspection and easy flow of visitors.

Some of the operating problems are equally challenging, since railroad cars are not normally operated on the continuous basis required by our schedule, and exhibits are ordinarily designed for a lifetime of a week or less in one place. These exhibits must look new for more than a year, and travel some 30,000 miles.

TRAIN EQUIPMENT

The 4500-hp locomotive which hauls the train also "doubles in brass" as an exhibit of general interest to all visitors, and of a particular interest to railroaders. It is equipped with the various types of train control and signal apparatus required for operation on all the railroads which it must travel during the tour.

The cars are new, modern, stainless-steel passenger coaches in which the seats and baggage racks are displaced by the exhibits. They were built by the Pullman Standard Car Manufacturing Company of Worcester (Mass.). To simplify their engineering and production, as well as their eventual disposal, arrangements have been made for the sale of the cars to the Chicago, Rock Island and Pacific Railroad when the tour is completed.

One major departure from the previous design for these cars is the 30-kw diesel-electric undercar power plant installed as regular equipment on each car. Electric power for lighting, air conditioning, water cooling, and the operation of the exhibits, plus about 18 kw of supplementary electric heat to each car is furnished by these units. They are trainlined and paralleled so that adequate power is available for all cars—even though one or more of the units may be shut down.

TRAIN EXHIBITS

Exhibits on the train are arranged in logical sequence, from the visitor's viewpoint, to demonstrate equipment and techniques for generating, transmitting, and distributing power, and for putting it to use in various productive ways. The train is displayed on two parallel tracks so that two rows of five cars each are arranged side by side, as shown in the heading of this article. This plan allows visitors to enter and leave the train at approximately the same point instead of emerging from the last car nearly a quarter-mile down track from the locomotive.

Most of the major exhibits go through an operating cycle automatically, or can be energized by the visitor. In fact, much of the exhibit material has been deliberately designed to put the visitor in the position of an actual user of the equipment. He can operate a model diesel-electric switching locomotive, for example, and a switcher and cars will do what he bids. He can control circuit breakers, lighting intensity, steel-mill speeds, or create a tiny snowstorm. He can even generate electricity, and, if he generates at a high enough rate, he will win a cigar. The objective, of course, is to make each exhibit as significant and as interesting as possible.

AS THE VISITOR SEES THE TRAIN

Visitors usually spend about two hours aboard, but any attempt to describe the many things they see can only be sketchy at best.

In touring the train, the visitor enters at the engineer's cab on the locomotive. After going through both its units, he passes the checking car, where he may leave his hat and coat, and goes on to the reception car. Here he is greeted by the local G-E representatives who have invited him to the train.

The first display presents a comprehensive story of the production of electric power by steam, gas, and mercury turbine-generators and by hydro-generators. Equipment for transmission and distribution is also shown. Immediately afterward are dramatized ways in which this power can be utilized through equipment engineered in combinations to perform the various types of jobs existing in industry today.

Equipment for materials handling comes next, where the visitor can control conveyors, lift-trucks, hoists, and cranes, in addition to the model switching locomotive.

Among the industrial heating equipment shown is a high-frequency induction heater display that heats a steel rod to glowing red in less than ten seconds. A welding display is built into a welding equipment store, complete with show window.

Fractional-horsepower motors, capacitors, ballasts, specialty transformers, and other components for industry are shown particularly for the benefit of manufacturers who incorporate these components into their own products.

Following is a scale model industrial plant with planned outdoor lighting for all purposes. The various lights on this display are synchronized with a tape recording which narrates the function of each type.

Many of the precise and efficient ways in which various processes can be controlled throughout industry are shown in the Measurements exhibit, as well as a large assortment of meters and instruments and special laboratory-built devices. An electric computer aiding automatic, continuous check of quality control is only one of the more than 250 different instruments in this display.

Dramatized for the visitor concerned with civic improvement are the latest equipment and techniques for street lighting, traffic control, smoke-density control, sewage treatment and water works, urban transit, and recreational lighting.

Of interest to all is the final unit which shows equipment for national defense. The famous J-47 jet aircraft engine is displayed, full size, with cutaway sections to show how it operates. Other equipment includes an operating aircraft gun turret, components of guided missiles, and models of apparatus for marine application and medical research. Some of the contributions to the development and constructive use of atomic power are also shown, including a demonstration of mechanical hands for handling radioactive materials.

CONSTRUCTION OF THE EXHIBITS

Most of the exhibits feature actual equipment, and some of it is surprisingly large. Falling in this category are the jet aircraft engine, unit substations, voltage regulators, motor-generator sets, and welding sets, for example. Heavy equipment of this type is secured through structural support members built into the car.

Floors in the cars are ¾-in. plywood over the corrugated sheet-metal bottom. This provides better weight distribution than would be possible with the flooring preferred for regular passenger car service. Side-wall support for exhibits is obtained by bolting through a channel at the point above the floor where the baggage racks are normally mounted.

Engineers C. S. Duckwald and C. A. Evans of the G-E General Engineering and Consulting Laboratory measure the strength of a sample section of train flooring. Extensive tests were made to be sure that the floor would be strong enough to hold the exhibits while in transit.

Exhibit loading of cars has been carefully calculated and planned to avoid unbalance. Exhibits are secured to withstand more than normal train movement by a safe margin. The total weight and accumulated center of gravity of all exhibits in each car is within the limits established by the car builder, and weight of the cars with their exhibits is essentially the same as their loading in regular passenger service.

All exhibits are supplied 220-volt a-c power along the full length of each side of the cars through Flex-A-Power raceways. Where 110-volt power is required, transformers and breakers are used in conjunction with the raceway supply.

With two exceptions, all exhibits were installed in the cars through the 6-ft, 6-in. by 2-ft, 4-in. end doors. The jet engine and the B-29 gun turret had dimensions requiring the removal of the end door-frame and diaphragm from one car for their installation.

On the inside, each car is 70 ft long, 9 ft, 5 in. wide, and 7 ft, 9 in. high at the center.

A review board made up of advertising and sales promotion men held frequent meetings to evaluate proposed ideas for the train exhibits. Here, one of the project supervisors explains an artist's conception of an exhibit telling about the High Voltage Laboratory.

TRAIN STAFF

Operation and exhibition of the train requires a staff and crew of about 40 men. The Tour Manager has an assistant and an accountant on his staff as well as a Service Supervisor in charge of car equipment and an Exhibit Maintenance Supervisor responsible for upkeep of the exhibits. Basic maintenance and servicing of the cars is performed by a Pullman Company crew which travels with the train and whose work is supplemented by Pullman terminal crews and railroad maintenance services.

The train is moved by regular crews supplied by the railroads over which it travels. Two Alco-GE representatives assigned to the train staff instruct train crews in the operation of the locomotive where necessary.

Exhibits on the train are supervised and demonstrated by a corps of twenty specially trained exhibit engineers supplemented by specialists and sales engineers from field offices of the G-E Apparatus Department. Two representatives travel in advance of the train to assure that all arrangements are in order as to exhibit site, train services and promotion, and staff accommodations.

SERVICES ON THE TRAIN

The train is equipped with a telephone system which is connected to the local system upon arrival. Three trunks are used for service and the system is controlled through a switchboard in the train office, which occupies a portion of the reception car. A wall-type dial telephone is located at the vestibule end of each car, while a removable hand set is installed at the outside of the locomotive car door while the train is on exhibit. A public-address system is used for paging and to provide recorded background music.

A fuel line for the undercar power plants, two three-phase 220-volt electric power cables, and a telephone cable completely interconnect all cars in addition to the normally trainlined compressed air and steam lines. The fuel-oil jumpers are disconnected when the train is moved, in accordance with good safety practice. When the train is placed in double-track display position, the connections are made from the engine to the head-end of both lines of cars, making it unnecessary to "loop" the system.

The fuel line connects a 1200-gal diesel-oil tank in the "B" unit of the locomotive with each of the 150-gal tanks on the exhibit coaches and a 300-gal tank in the baggage-dormitory car, for conveniently refueling the undercar power plants. A pump on the locomotive supplies pressure ranging from 12 to 65 psi to deliver the oil, while tee connections on each car provide selective loading.

An electrically driven auxiliary compressor in the locomotive provides air pressure to operate the automatic doors in the coaches, for the water tanks, and for some of the exhibits.

Two 3000-lb per hr flash-type steam generators, one in each unit of the locomotive, produce steam for hot water and heat as necessary.

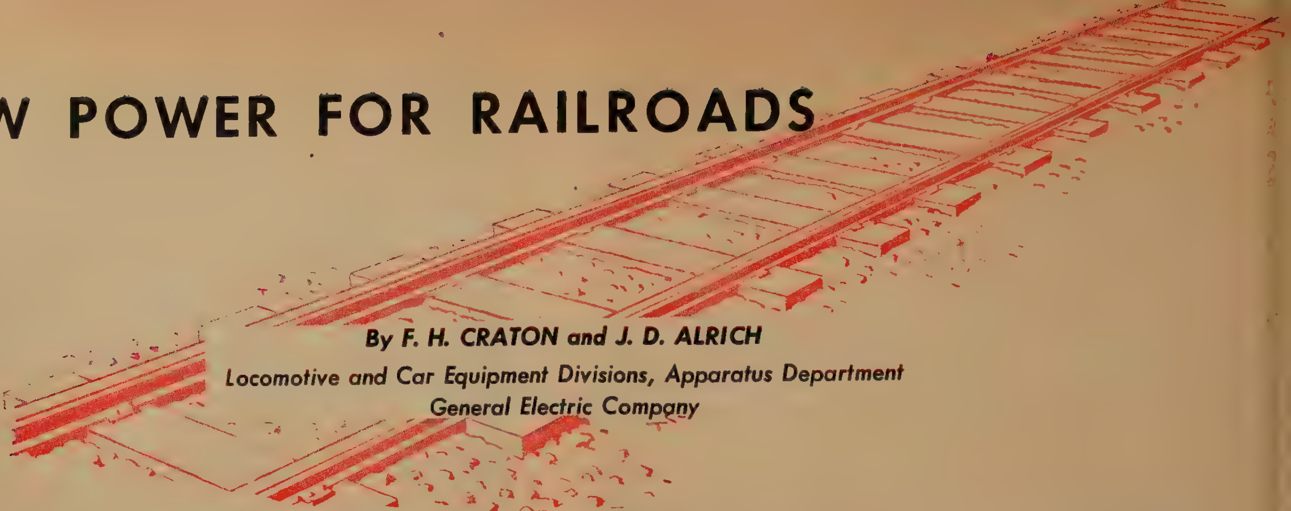
DEVELOPMENT OF THE TRAIN

Intensive work on the MPA Special began early in 1949, although general plans for it had been under consideration for about five years before that time. Several hundred people within General Electric took part in developing and executing the various phases of the project. The services of six exhibit companies were used to build and install the displays, and many of the intricate operating equipments were designed and constructed by G-E product divisions and laboratories.

Physically, the train simulates a packaged tour through 31 factories producing electrical apparatus, and as such it is undoubtedly the largest industrial showcase and sales kit ever built.

From the broader standpoint, it is a bold dramatic vendor of ideas—ideas for further electrical progress and More Power to America.

NEW POWER FOR RAILROADS



By F. H. CRATON and J. D. ALRICH

Locomotive and Car Equipment Divisions, Apparatus Department
General Electric Company

THE theme Newest Design echoes throughout the More Power to America Special. The fire-engine-red Alco-GE locomotive, "Big Red" as she is called by all who know her, looks just like her older sisters operating on the railroads of America. Actually, however, she embodies refinements which make her the most modern diesel-electric locomotive in service today.

Here may be seen the prototype of the new-model Alco-GE locomotives. Her two units have an over-all length of 127 ft and a total weight of 302 tons. Geared for a top speed of 90 mph, her electric equipment enables her to develop 74,000 lb tractive effort continuously at 19 mph. For starting a train, she can exert a pull of the order of 120,000 lb.

Each unit contains a 16-cylinder turbosupercharged engine, the two developing a total of 4500 hp. Electric driving motors, of the latest design, develop greatly increased tractive effort. The latest version of the Alco-G-E electro-hydraulic governor controls the engines' output, and actually anticipates the need for power. Improvements add up to a 12½ percent increase in horsepower and a 25 percent increase in continuous tractive effort over former models of the same size and weight.

"Big Red" is a symbol of one of the greatest developments in the history of railroad motive power—the swing to electric drive. Railroad motive power may be divided into two groups, depending upon the means used to transmit the propelling energy to the driving wheels. Roughly three quarters of all locomotives today use steam for this purpose. The remainder employ electricity, and are known as various types of electric locomotives. They are the insurgents that have caused the revolution. What are their characteristics and importance in the railroad picture today?

DIESEL-ELECTRIC LOCOMOTIVES

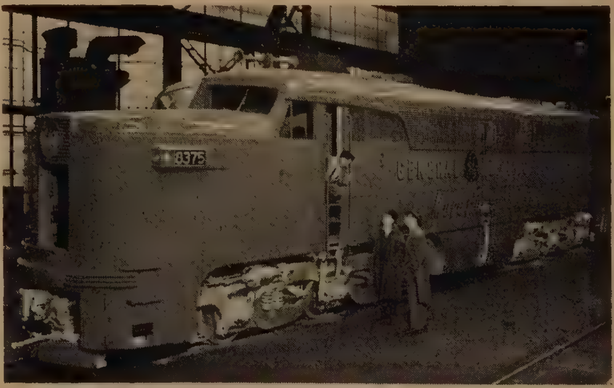
The diesel-electric locomotive easily tops the list with almost universal acceptance by the railroads. It is a combination of the highly efficient diesel engine with the smooth flexible power delivery of the electric drive.

American designers first united these elements in a successful locomotive in 1924. In July of that year, the *New York Evening Post* stated that this pioneer diesel-electric had "shown results so remarkable that they foreshadow a revolution in electrical and railway engineering"—prophetic words indeed.

By 1937, the diesel-electric had invaded all classes of railroad operations. The seeds of revolution were sown, though wartime restrictions delayed their maturing. But in 1946, the real upsurge started and has continued unabated to the present.

At the beginning of 1950, American railroads had almost 14 million diesel-electric horsepower working for them. Last year, according to Dr. J. H. Parmelee* of the American Association of Railroads, these locomotives accounted for "nearly one-half (48 percent) of total car-miles in passenger service, nearly one-half (48.9 percent) of the locomotive hours in yard service, and nearly one-third (33 percent) of the gross ton-miles in freight service" on our railroads. This record is even more impressive because it was made by a trifle over 20 percent of the locomotives owned by the carriers. Referring to American railroad motive power purchases, *Railway Age** says: "Substantially all of the billion dollars spent for locomotives during the last four years has gone for diesel-electric locomotives."

The diesel-electric locomotive battled its way to the top against heavy odds. It won by showing that it could do a big sector of our transportation job more economically than its competitors.



Close-up view of the "A" unit of the Alco-GE locomotive which hauls the MPA Special, taken in the shops of the American Locomotive Company. The "B" unit is similar as to power plant, but has no operator's cab.

**Railway Age*, vol. 128, no. 1—Jan. 7, 1950.

To be specific—the diesel-electric's fuel bill is only a third to a quarter of that for a comparable steamer. Labor costs are cut 20 to 40 percent through more efficient operation. In service expense, actual material and labor are less, and the elaborate coal, water, and ash-handling facilities required by steam power are no longer necessary, if the changeover to diesel-electrics is 100 percent. These savings are sufficient to pay for the investment in diesel-electrics in five to eight years.

A locomotive must be ready for service when it's needed. Here is one of the diesel-electric's strong points. Capable of carrying enough fuel for extended periods of operation, and requiring relatively infrequent maintenance, these locomotives have achieved an enviable record for dependability. Conservative findings are that the average diesel-electric is available for use something like 90 percent of the time.

Good forward visibility is a feature of locomotives like the one on the MPA Special. Here the engineer has leaned aside to give the camera a clear view down the track.

Another point in favor of this type of motive power is its versatility. The same locomotive may be used for a number of different kinds of work. As an example, take the new Alco-GE 1600-horsepower road switcher. This unit is designed fundamentally as a switching locomotive. However, it is equally at home pulling freight or passenger trains. On some roads, its working schedule calls for operation in all three types of service within a 24-hour period.

Motive-power men have discovered that, on the average, one diesel-electric will often replace more than one steam locomotive in the same type of service. Capable of starting heavy trains without the jerk of "taking slack," they reduce damage to equipment and lading. Their smooth-running motors are easy on the track, which helps cut bills for maintenance of way.

ELECTRIC LOCOMOTIVES

In 1895, the Baltimore & Ohio Railroad installed the first main-line electric locomotives in America. Faced with the difficulty of operating through a two-mile tunnel under Baltimore, this road turned to electric traction to eliminate the smoke nuisance. From that day on, electric locomotives have been doing special and difficult jobs in the railroad business. They make possible our mid-city terminals with underground approaches, such as Grand Central and Pennsylvania Stations in New York. They handle the traffic of our busiest main lines on the New Haven and Pennsylvania. They increase the capacity of our heavy mountain grades and tunnels as on the Virginian, Great Northern, and Milwaukee Railroads.

This veteran of the electric-drive locomotive family is a converter instead of a generator of power, which is the secret of both its limitations and advantages. For this locomotive to operate, a trolley wire or third rail must be installed. Such construction, together with the substations to furnish the power at proper voltage for locomotive use, must be included in the cost of electrification of the railroad.

Overload Capacity Available

But there are advantages to this set-up. The remote power station gives the superiority of overload capacity, which is not available in a locomotive that carries its own source of power. For instance, the capacity of a diesel-electric locomotive is usually rated about to the maximum output of its diesel engine, meaning no overload capacity to speak of. On the other hand, the electric can draw from the relatively unlimited capacity of the power house. Since its motors are designed to carry overloads for limited periods, it can develop power considerably above its normal rating for short intervals. Thus the electric locomotive can accelerate trains faster and negotiate limiting grades at higher speeds than any other type of motive power.

For example, a famous New York-Washington limited is hauled by a streamlined electric locomotive having a continuous rating of 4600 hp. When necessary, this engine can exert as much as 8500 hp for short intervals. With electric operation, it has been possible to cut 40 minutes off the former steam locomotive schedule for the 225-mile run.

Diversity Factor Is Advantageous

Another advantage of the electric locomotive arises from its "diversity factor." Each locomotive draws from the central station only whatever power it needs at any particular time. Since only a few will be demanding maximum power at the same time, the total output of the station will be considerably less than the sum of the individual locomotive ratings. Hence the electric locomotive can do a given transportation job with less total power generating capacity than any other type of motive power.

Economics is one of the prime factors in determining the future of the electric locomotive. Electrification

Any "car knocker" can make trainline connections for the undercar power plants as easily as he can connect the hoses for the air-brake system.

involves a large initial capital expenditure, hence it can be justified only on the basis of heavy traffic or unusual operating conditions. Where these exist, it will—to quote H. C. Griffith, Chief Electrical Engineer of the Pennsylvania Railroad—"produce faster, better and more reliable service with fewer locomotives and greater economy."

Active research is continually being carried on in the field of electric traction. Further improvements will, doubtless, maintain or improve the competitive position of the electric locomotive in the transportation picture.

GAS-TURBINE ELECTRIC LOCOMOTIVES

A new recruit in the motive power ranks is the gas-turbine electric locomotive. Essentially, it is a diesel-electric locomotive with a gas-turbine power plant in place of the diesel engine. The electric drive and controls follow, as far as possible, conventional diesel-electric practice.

This locomotive is a marvel of compactness. The gas-turbine power plant develops one hp for every six lb of weight, or 53 hp per foot of length. It is rated at 4500 horsepower—the equivalent of three conventional 1500 horsepower diesel-electric freight units.

What is the probable place of the gas-turbine electric locomotive on the railroad motive power roster? One important factor in determining what it will be is the item of maintenance. The power plant of the demonstrator locomotive was designed to operate three times as long as a diesel engine between major overhauls. It is too early as yet to say whether expectations will be met completely. In any event, great economies in maintenance costs are almost sure to result.

The question of fuel also plays an important role. The pilot unit was designed to burn Bunker C oil—a low-cost residual fuel. As long as there is sufficient price differential between this and diesel fuel, the balance will be in favor of the gas-turbine electric. The gas turbine also offers considerable possibility of some day burning coal. Should this develop practically, it could change the whole picture for the Eastern roads.

During the first year of test operation, this locomotive met the expectations of its designers, but only many miles of operation in revenue service will determine what it is really worth.

UNDERCAR ENGINE GENERATOR SETS

One seldom thinks of the conveniences found in a modern streamliner—its fluorescent lights, air conditioning, electric water coolers, finger-tip door controls, convenience outlets, telephones, public-address system, and all-electric diner—in terms of the electric bill. A fifteen-car train may require as much as 750 kw to cater to the comfort and convenience of travelers.

In most cases, this power must be furnished by the locomotive and, at times, it may amount to a third as much as the total power required to pull the train. This worries railroaders because it means that one quarter of their locomotives in passenger service are really power houses on wheels that must be carried along to supply the electrical needs of the train. This is necessarily expensive and inefficient. Small wonder that the railroad fraternity is looking with great interest at the self-contained power plant under each car.

The question of power supply for passenger cars first appeared in July, 1887, when the Pennsylvania's "Chicago Limited Express" included electric lights in the equipment of its "gorgeous examples of parlour and sleeping cars." For the first month the power was supplied by storage batteries charged in New York and Chicago. Then a steam-driven generator was installed in the baggage car, but certain basic weaknesses prevented its wide acceptance.

In an effort to make each car an independent unit, a generator belted to one of the axles was installed in conjunction with the car battery. This system, with modifications, is the one found in use today on a majority of passenger cars.

Axle Generator Requires 90 hp

The introduction of air conditioning in the 1930's, and the increasing use of electricity for other purposes in passenger cars, imposed a rapidly mounting load on the power-supply system. It is not unusual for a modern car to be equipped with an axle generator delivering as much as 45 kw, and a battery weighing 2½ tons and costing upwards of $4000. But this is only half the story. Every such car in a train requires 90 hp from the locomotive to operate its generator. With present diesel-electric locomotive prices averaging $115 per horsepower, this represents an investment of $10,000 in locomotive power to drive the axle generators.

Such a set-up is cumbersome and inefficient. Counting idle time and slow running, the average output of an axle generator is only 60 percent of its rated capacity, and hard operating conditions shorten battery life. The transmission by the train itself of the driving power all the way from the diesel engine in the locomotive to the generator under the car is also inefficient.

Early attempts to solve this problem with a power plant under each car met with failure, largely because no reliable engine was available. As a result of building small diesel-driven power plants for the armed forces, where reliability was a must, engine manufacturers produced an engine sturdy enough to be put under a railroad car and operated day in and day out, with a minimum of routine inspections between overhauls.

The generator of the undercar power plant must also stand severe electrical abuse. It not only must be able to start a large air-conditioning motor while carrying the rest of its normal load, but must stand being "thrown" on the line to operate with other sets on the train at any time. This may, at times, amount to a short circuit on the generator. After some effort, a machine was designed that fulfilled all requirements well.

Swings Out for Inspection

The problem of putting such a power plant in the limited space under modern low-slung cars was exhaustively studied. As it exists, the power plant is housed in a box to protect it from flying missiles that can be encountered under a train traveling at high speed. The assembly can be swung out from the box for easy inspection and maintenance, or can be completely replaced in a matter of minutes.

Two trial units were mounted under a test car at the factory. Satisfactory provisions for clean air intake and exhaust gases were made. To keep noise and vibration to a minimum, the complete unit—box and power plant—was mounted on rubber and flexible connections made to all pipes running into the box. So successful was the final result that, even with the car standing still, it is difficult to hear the set running.

One question remained to be answered—could sets operating on different cars be connected together without a lot of "gimmicks?" With the test sets running, the connecting switch was closed at random several hundred times. Careful observation was made of electrical and mechanical effects. It was found that under the worst possible conditions, the sets quivered and the engines labored for an instant, but after that the load was shared properly.

A pair of demonstration units was installed on the "Cafe St. Louis"—the all-electric dining car of the Illinois Central Railroad that attracted so much attention at the Chicago Railroad Fair. Another pilot installation was made on a private car of the Atlantic Coast Line. The success of these "guinea pigs" aroused widespread interest among railroad men. As a result, other lines negotiated for trial sets, some of which have already been placed in service.

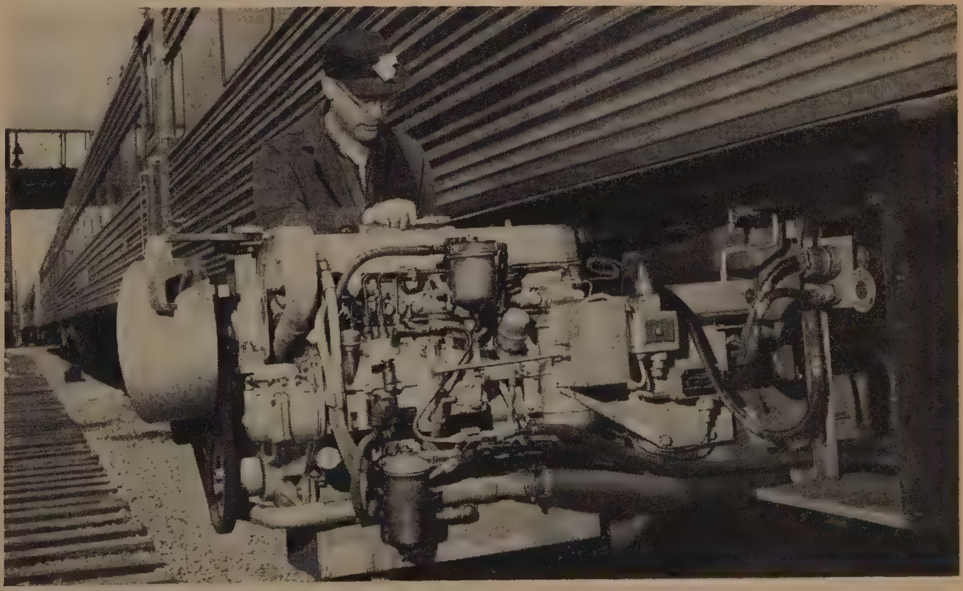
Incidentally, heat is available from the engine exhaust and from the electric-power capacity required for cooling in summer. It may be used advantageously for heating the car in winter, which thus lowers the demand upon the train heating boilers in the locomotive.

The More Power to America Special is one of the first trains in the United States to be completely equipped with such power plants. One is located under each car to supply its normal electrical load and a good share of its heating. Four sets in the baggage car furnish extra power for operating exhibits on the train. Because of this equipment, the train is entirely independent of outside power supply. The entire 4500 hp of the locomotive is available for hauling the Special, instead of being slashed by nearly a quarter to provide electricity for the cars.

CONTRIBUTES TO ECONOMICAL OPERATION

Railroads have invested hundreds of millions of dollars in modern streamliners as one of the best means of attracting business. The diesel-driven power plant can contribute substantially to the economical operation of this new equipment by permitting expensive motive power to be used for its primary purpose—hauling trains, and by reducing the maintenance cost on passenger-car power-supply equipment.

All equipment of the More Power to America Special exemplifies the newest designs of railroad apparatus. In it is seen another forward step in providing the railroads with better and more efficient tools to enable them to maintain leadership in a free and competitive transportation economy.



One of the undercar power plants of the MPA Special in swungout position for the workman to inspect. One of these units can be completely replaced in a matter of minutes if the need should arise.

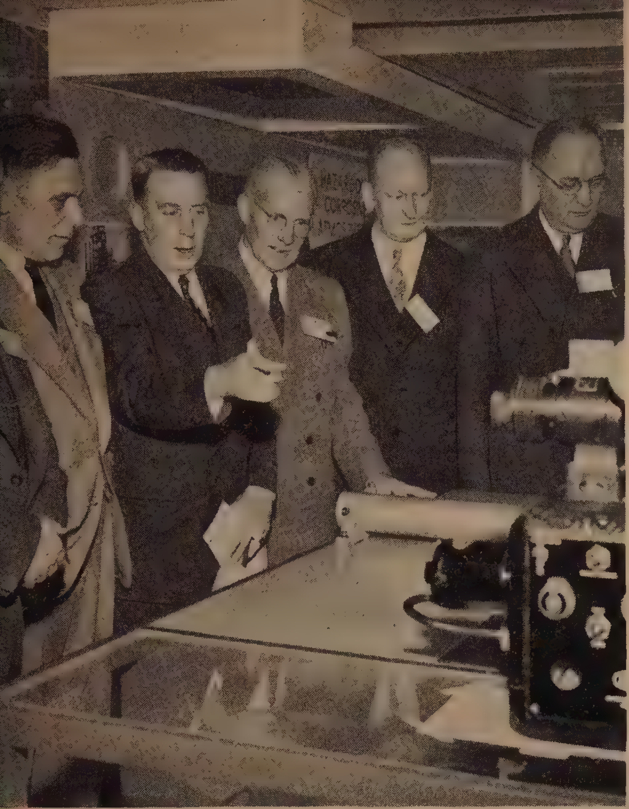
On tour with the Special

President Charles E. Wilson (left), of General Electric, converses with Gustave Metzman, president of the New York Central Railroad, after the dedication of the MPA Special in Grand Central Terminal, New York City. Mr. Metzman was one of a number of representatives of utilities, industry, transportation, and the government present.

Governor Thomas E. Dewey, of New York State, tries his skill at operating the mechanical hands in the National Security exhibit aboard the MPA Special in Albany (N. Y.) while Vice President H. V. Erben, of the G-E Apparatus Department looks on. Hands of this type are used in atomic energy work to handle radio-active materials, thus protecting the worker from possible dangerous after-effects.

Col. G. C. Coleman and Lt. Col. H. D. Davidson, of the Air Force Cambridge Research Laboratory, Cambridge (Mass.), examine the cutaway model of a J-47 jet engine with R. G. Bennett, sales engineer from the G-E Boston office. By operating the throttle, visitors to the train can control the speed of the engine. These officers visited the Special in Boston (Mass.).

General Electric stockholders go aboard the MPA Special at it very first showing during the annual stockholders' meeting at the G-E Schenectady Works. Although the locomotive was not open this day, visitors ordinarily start their tour through its two units. The train is shown lined up in regular double-track display arrangement with five cars on each side. In this way a visitor will leave the train at nearly the same place as he enters.



In each community visited by the train, a gold key is presented to its civic leaders. At this presentation in Buffalo (N. Y.) are Council President Peter J. Crotty, Mayor Joseph Mruk, Vice President A. T. O'Neill, of the Niagara Mohawk Power Co., William J. Woods, of G.E., and Edwin S. Bundy, vice president and chief engineer of Niagara Mohawk.

A. M. Wainright, of the G-E New York (N. Y.) office, tells about the "electronic bloodhound" cutting torch control while A. T. Larned and T. G. Seal of Ebasco, E. Woodhead, chief engineer of Idaho Power, and Roy E. Penman and C. H. Reper of Ebasco listen. This control follows a silhouette drawing to produce highly accurate torch-cut shapes.

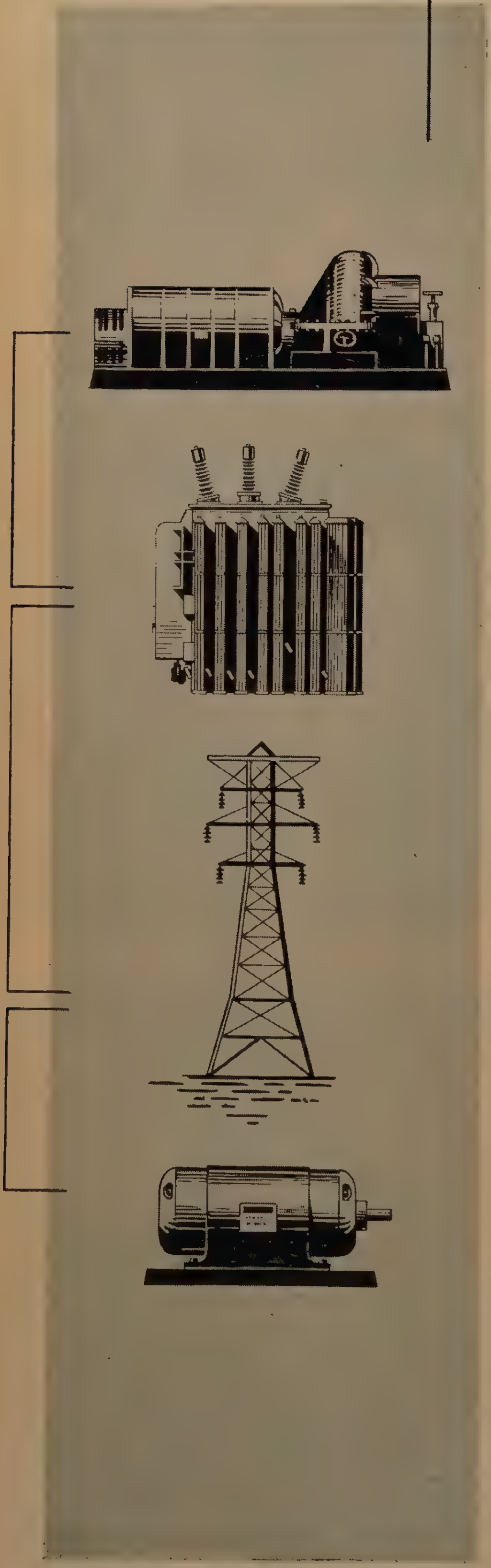
Executive Vice President H. C. Forbes, President H. Roy Searing, and Chairman of the Board R. H. Tapscott, all of Consolidated Edison, together with George Rose, a G-E pensioner, an MPA Special exhibit engineer, and W. F. Anselm, of the G-E New York (N. Y.) office, discuss impulse circuit breakers.

The technical
and economic
significance of
developments
and trends in . . .

the production and application of

ELECTRIC POWER

past . . . present . . . future



The secret of America's economic strength, a pillar of hope to freedom-loving peoples today, is its tremendous capacity to produce. This capacity, increased manyfold during the past half-century, is directly attributable to the abundant production and application of electric power by progressive industry operating within the framework of a free enterprise system. Due to continuing technical development and the ever increasing use of electricity, the American industrial miracle of MORE GOODS FOR MORE PEOPLE AT LESS COST is being carried on and even accelerated. The More Power to America Special, with its displays of the newest electric products, systems, and techniques, is helping to disseminate ideas that will still further increase the pace of progress. The following pages of text, and of photographs of exhibits on the MPA Special, describe how these mid-century ideas for efficient generation, transmission, distribution, and utilization of electric power can be put to work for the greatest benefit of all.

The technical
and economic
significance of
developments
and trends in . . .

POWER GENERATION AND TRANSMISSION

By R. C. BUELL
Central Station Engineering Divisions, Apparatus Department
General Electric Company

THE mightiest servant the world has ever known is only 68 years old. Born Sept. 4, 1882, when the Pearl Street Station in New York City was started, this infant electric light and power business had grown to lusty childhood by 1900, with 1,700,000 kw of generating capacity installed, and each kilowatt producing about 1000 kw-hr per year. By 1925, 22,000,000 kw had been installed, 13 times the capacity of 1900, but the load factor had so increased that 36 times the total kilowatt-hours of 1900 were being generated. After another quarter century of tremendous growth, today's installed capacity is 2.75 times that of 1925, and about 4 times as many kilowatt-hours are generated.

What can be expected in this next quarter century? Will the power industry continue to double every 10 years as it has been doing, and reach the almost fantastic figures that have been predicted for it?

Here then, is a brief picture of this genie that has grown from the Aladdin's lamps of 1882, examined in the light of its components.

GENERATION

Of the total of 291 billion kw-hr generated in 1949, 30.8 percent came from hydro stations, 69.2 percent from fuel. The steam turbines that produced most of the larger portion of this energy started from a humble beginning 50 years ago—small units of 2000 kw or less. By 1925, the steam turbine completely dominated the central-station field. The biggest units installed at that time were 80,000 kw at 1800 rpm. The 3600-rpm unit was limited to about 7500 kw in size, largely by turbine problems.

Due to the use of alloy steels, the steam turbine of today has grown to mammoth size. Turbine steam conditions have increased from 500 psi at 700 F in 1925 to 2000 psi at 1050 F. Not only has the heat rate of the turbine itself been improved, but, with other improvements in steam stations, nearly two times as much energy per pound of coal is being produced as in 1925. Single-shaft units are now being built up to 165,000 kw at 1800 rpm and 125,000 kw at 3600 rpm.

During the next quarter century, turbines will continue to grow in size as power systems expand and better materials become available. Machines generating 150,000 kw at 3600 rpm are in the near future, and 1800 rpm machines can be foreseen up to 200,000 or 300,000 kw—even 500,000 kw may be a possibility. Although many problems are ahead, the next 25 years will see turbines operating with inlet temperatures and pressures so high that the ingoing steam will have the same density as water. Nothing seems a logical contender for these big units within the next few years.

THE MERCURY CYCLE

While the steam power plant was being brought to its high state of perfection, engineers were working with another heat transfer agent—mercury. A small installation was made in Hartford (Conn.) before 1925. Today, four mercury-steam stations are in operation. The new Schiller Station at Portsmouth (N. H.), on the Public Service of New Hampshire system, consists of two 7500-kw mercury turbine units feeding steam to a 25,000-kw steam turbine.

Tests indicate that the expected over-all heat rate of the plant, using oil as a fuel, will be about 9200 Btu/kw-hr, which is better than could be obtained with any other kind of plant of the same size. The mercury cycle looks very favorable in locations requiring small plants under 100,000 kw, in areas where fuel is expensive so that high efficiency of operation can be justified, or where condensing water is scarce or of poor quality.

J. W. Belanger (left), assistant general manager of the G-E Apparatus Department, and E. E. Parker, manager of engineering, Turbine Divisions, examine actual turbine components on display aboard the MPA Special.

THE GAS TURBINE

A new prime mover, the combustion gas turbine, is just beginning to appear as an important contender for some specific power generation applications. Some work had been done as early as 1900, but little evident progress was made in the first quarter-century. During the next 25 years, new materials capable of withstanding high temperatures were developed, and the war development of the jet engine, a special application of the gas turbine, greatly enlarged the field of knowledge on this subject. The 3500-kw unit of the Oklahoma Gas and Electric Co., installed in the summer of 1949, has had over 6000 hours of operation with natural gas as a fuel; another 3500-kw unit was started by Central Maine Power Co. this year. These are simple-cycle turbines with a station thermal efficiency of about 17 percent. A 5000-kw regenerative gas turbine has just completed its tests and a second has only recently been placed on test. Their efficiency, due to the more complete cycle, is expected to be about 28 percent. Bigger turbines are expected soon.

These gas turbines find their application at the present time where low-cost oil or gas is available, or where cooling water for a comparable steam turbine is costly. They have a lower installed cost than a comparable size steam turbine, and completely automatic operation appears feasible. Because of small size and weight, they appear suitable for mobile plants. The improved efficiency and lower operating cost which can be expected in the next few years will mean many places for them in power systems.

HYDRO-ELECTRIC GENERATORS

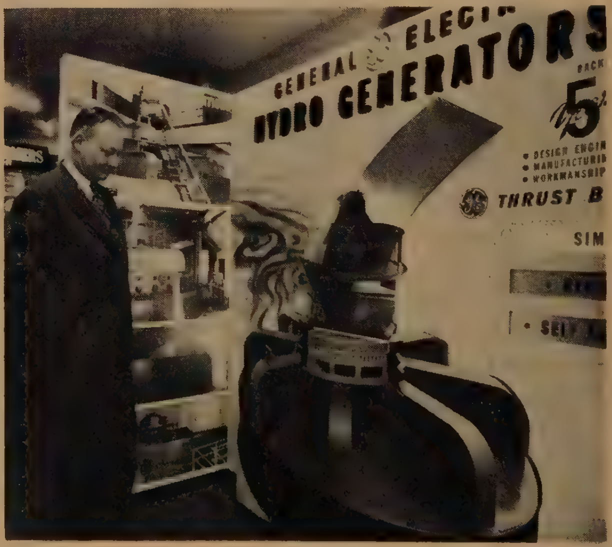
Water power, one of the first sources of mechanical energy, can be traced back by historians over 3000 years to the crude current wheels used by the Chinese on the Yellow River and by the Hamites on the Nile. It built the mill towns of New England during the 19th century, but by the dawn of the 20th century hydro-electric generators were replacing the earlier mechanical-drive shafts. Units as large as 5000 kw were installed by this time, and, during the first 25 years, a very rapid growth in installed capacity took place under private utility leadership. Developments of most all of the available economic sites within reach of loads had been started, and by 1925 units of 65,000 kva, such as those at Niagara Falls, were installed.

Engineering developments, resulting in lower costs, made steam power generally much more economically justifiable in comparison with hydro so that today, of the 60 million kilowatts installed in this country, only 16 million kilowatts is in hydro-electric generators. Most of these are vertical generators, and one of the unique design problems has been the thrust bearing to carry the heavy rotating mass of the field and its connected water turbine. The spring thrust bearing, first used in the second decade of this century, continues doing a reliable job, being designed each year for bigger loads. At the present time one is in operation carrying a load of three million pounds at 75 rpm, while a bearing to carry four million pounds is under construction.

THE GENERATING STATION

Generating stations have seen a major change in their fundamental requirements during the past years. The wheel of progress has, in some respects, made a complete revolution. In 1900, a generating station was basically characterized by one generator, perhaps a step-up transformer, and one line or feeder going out to supply the load. The electrical control of the generator might be characterized by a knife switch and rheostat for the field. Open the waterwheel gate, close the field switch, and the station was in operation. Twenty-five years later, stations usually had several generators. Reliability of service was the watchword. An elaborate generator bus with circuit breakers, several transformer banks, and an extensive high-voltage bus supplied the system. Reliability of the system depended upon the single station. Tie lines to other stations could not be relied on under adverse conditions.

Today the generating stations are repeating some aspects of the simplified arrangements of 50 years ago. Reliability is now thought of in terms of the system, rather than of the individual station. This simplification of the generating station has been possible because of the greatly improved performance of its components. Today in many stations, the generator is connected directly to its step-up transformer bank, thereby eliminating the expensive low-voltage switching arrangements.



J. M. Crawford, manager of the G-E Large Motor and Generator Divisions, inspects a mock-up model of a hydro-generator in which the thrust bearing is highlighted.

Simplification has taken place also in the auxiliary power supply for the stations. Unit and load-center substations, completely metal-enclosed, have replaced the maze of switches and control devices scattered throughout the station. The trend is toward complete centralization of all control functions, mechanical as well as electrical, in one operating room, and more recently on a single control board.

LARGE GENERATING STATION SWITCHGEAR

Many of the older steam stations located along the waterfronts of our larger cities are being rebuilt with modern large steam turbines. Single boiler units of 100,000 kw are being put in the physical space of the 15,000-kw units of 25 years ago, and their output goes to load in the immediate area directly at generator voltage. Such concentration of power at the lower voltages requires a different treatment from that of previous years. Open buses are a hazard to operating personnel and continuity of service. To meet today's operating requirements, all breakers, disconnect switches and buses are metal-enclosed, and air-blast breakers will clear short circuits up to 2.5 million kva in the 14.4-kv class.

It now appears that the increased difficulty of transmitting large amounts of power away from the generating station may curtail the need for increased interrupting and continuous current capacity in this type breaker. Already, one of the largest companies has found it desirable to step up from generator voltage to 69 kv, even though the load area is but a short distance away. This saves expensive space, switching equipment, and bus reactors in the generating station.

TRANSFORMERS

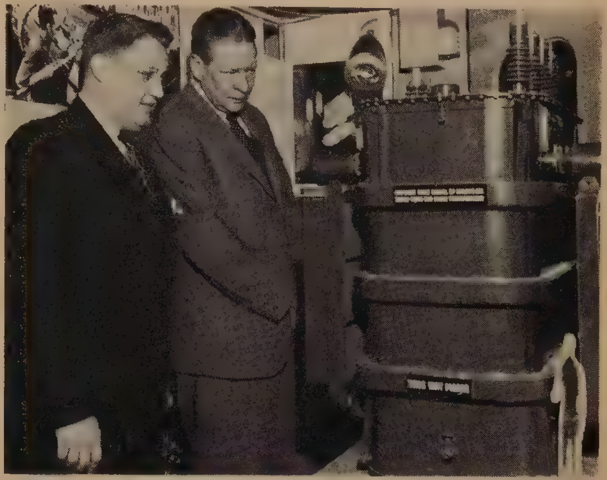
The development of better core iron has brought down iron loss year after year. For example, the core loss of the modern 50,000-kva self-cooled transformer in the 69-kv class is only 0.2 percent and the total loss at full load less than 0.6 percent. Due largely to the increased reliability of all transformers and the savings made by elimination of the external bus work, the three-phase transformer is generally used in the large sizes instead of three single-phase units. Along with this change has come the wide acceptance of auxiliary means of transformer cooling, such as forced air, forced oil, and combinations of these means. While resulting in some decrease in efficiency, because the copper and iron are worked at higher densities, it has allowed cost and size reductions that permit economical application in many locations. For practically no increase in size, and approximately 20 percent cost increase, a transformer with a self-cooled rating of 10,000 kva or larger can be increased 67 percent by means of forced-air cooling.

Another means of reducing size and cost appears as a certainty for tomorrow. With the better understanding of proper proportion of insulation, and the superior protective level afforded by the modern lightning arrester, it is apparent that lower insulation levels can be used on transformers, particularly at higher voltage levels.

The conflict of tomorrow in transformer design will be efficiency versus cost and size.

LIGHTNING ARRESTERS

Early in the development of the power industry it became obvious that reliable power could not be supplied without protection from lightning. During the first quarter of this century, protection was handicapped by a complete lack of any information regarding the voltage, current, and duration of lightning strokes. In the past 25 years, however, research yielded quantitative data on the nature and hazard of lightning so that it could be effectively duplicated in the testing laboratories. Today, the modern Thyrite* arrester will safely limit lightning stresses to about one-half of apparatus insulation strength. Continued lightning research on insulations and protective equipment will further improve the economics and reliability of co-ordinated protection.



This one-sixth scale model represents a 100,000-kva, 70,000- to 13,200-volt power transformer. The man's figure by the base gives an indication of its size.

SUPERVISORY CONTROL

Just to keep a station operating was enough of a problem years ago to justify all the manpower needed. Today, in the operation of any system, there is an extreme consciousness of the yearly cost of a shift of operators whose major function consists of being at the station "just in case." Now, telemetering and supervisory control, combined with automatic equipment operation, makes it possible to put the major part of the system operation directly under the fingertips of the load dispatcher. He can control frequency, voltage, tie line loads, perform switching operations, and start and stop generators. More and more of the system operation will be in his hands in the future; maintenance and observation will be the function of the future station attendants, rather than operation.

SYSTEM RELAYING

Protective relaying has also made a revolution on the wheel of progress during the half century. Practically unknown and unused at the beginning, the relays gained in acceptance until they influenced to a considerable degree the design of the system. Now, due to the development of distance, reactance, and similar "calculating" relays, and the carrier-current relays, correct protection can be given to almost any system configuration. While more expensive than the simple overcurrent and balanced relays of years ago, they are cheap compared with more elaborate system configuration previously required to obtain the same reliability.

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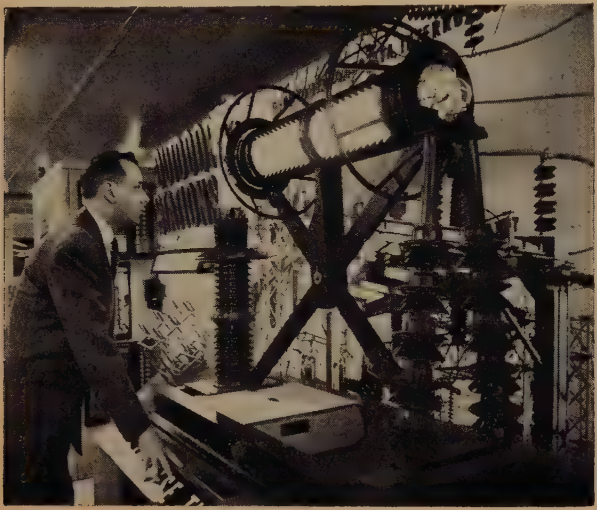
* Registered Trademark of the General Electric Company.

The tremendous increase in size of the power systems and their interconnections by the end of the first quarter-century emphasized the need for improved system stability. High-speed excitation, governor control, and switching were tried; the high-speed switching produced the greatest gain. With breakers capable of clearing a fault in three cycles, it was necessary to produce relay systems that would be comparably fast if the maximum gains were to be realized. Today's relays calculate the location of the short circuit and close the trip circuits of the proper breakers in one or two cycles.



By pushing a button, visitors to the MPA Special can send this scale model of a 230-kv impulse type breaker through a slow-motion operating cycle. They can see the arc-breaking mechanism through the plastic case.

OUTDOOR AND HIGH-VOLTAGE SWITCHGEAR

The growth of systems and the transfer of responsibility for continuity of service from the individual generating station to the system as a whole has required increased interrupting capacity, shorter interrupting time, fast reclosing and improved reliability from high-voltage breakers. This has been met by continued improvement of the conventional tank-type breaker and development of the impulse breakers. As it became necessary that system stability be greatly improved by getting short circuits off the system quickly, interrupting times were reduced, first from 20 or 30 cycles to eight cycles, and now breakers are available that will clear a 10 million-kva short circuit in three cycles, and reclose in 10 cycles, if needed. The speed of reclosing in the future will be dictated by the deionization time of the air in the short circuit on the transmission line, rather than breaker design limitations.

The hundreds of substations being built all over the country, each made up of many similar components, have made logical the use of standard components in their construction. This building-block approach to substation design and construction has been a most effective means of lowering the installed cost and promises even greater benefit with wider application in the future.

TRANSMISSION

Transmission of electric energy was well under way at the start of the 20th century. Single-phase transmission at first, then two-phase, and finally three-phase, was used. By 1900, voltages as high as 55,000 were in use in this country. By 1925 the Southern California Edison Co. had already started operating some of their lines at 230,000 volts. This last quarter-century has seen only one increase—to 287 kv. The great strides of the first quarter-century reached voltages as high as were economically necessary, and now the industry looks ahead to the next phase of power transmission.

Two areas may show a need for further increasing the voltage. In the industrial east, where tremendous systems are interconnected, a higher-voltage backbone will be needed to permit easier transfer of large blocks of energy from one area to another, resulting in greater operating economies in meeting regional requirements and diversity of the load. This may be met with transmission at 230 kv, already existing in some sections; but it is quite probable that a higher voltage will be used, as 230 kv is not quite enough better than the existing 115- and 138-kv systems.

In the western part of the country, the development by the federal government of large hydro-electric power concentrations, remote from load, may also necessitate higher voltages to utilize the entire capabilities of the development. One more step-up in voltage, perhaps to 360 kv, should be adequate to meet both these cases. It would appear that there must be a major change in economic and engineering conditions that exist today to justify any voltage above this level.

To meet this possible need for a higher operating voltage, development has already been well advanced. Transformers, circuit breakers, and other transmission equipment for voltages up to 360 kv have been built and tested. It only remains to prove the economics of the application.

The cost of the components of transmission systems goes up very rapidly with the operating voltage. However, it has been demonstrated by operating experience that the use of the modern lightning arrester will permit the use of the next lower insulation class, resulting in an appreciable reduction in the cost of equipment.

PREDICTION—IN BRIEF

What, then, does the next quarter-century hold for the power industry?

It can look forward to the establishment of major backbone interconnection between areas at higher voltages, huge generating stations—fuel and hydro—of two to three million kw capacity, with energy being carried from these stations on four to eight high-voltage lines, and the existing systems and lines growing to fill in the distribution from the higher voltage backbone.

An annual peak of 175 million kw does not appear to be unlikely.

The technical
and economic
significance of
developments
and trends in . . .

POWER DISTRIBUTION

By D. K. BLAKE
Central Station Engineering Divisions, Apparatus Department
General Electric Company

GOOD tools in the hands of skilled craftsmen promote good workmanship. Good tools in the hands of a resourceful distribution engineer result in a better distribution system at a lower cost.

Until the recent war and postwar system expansion, most distribution systems were built with old and inadequate tools. In fact, most of our modern distribution implements were developed just prior to and during the depression, but not until the postwar expansion have we had real opportunity to reap the full benefits they make possible.

While the distribution transformer is not a new type of tool, it has been the subject of intensive development in recent years. Because of that development, which includes highly standardized design, it now represents the biggest dollar value in electric apparatus. Continued progress in reducing its weight and losses, combined with increased reliability, has contributed substantially to reducing its installation and operating costs as well. As loads continue to grow, from year to year, the combined cost of distribution transformers and their losses increase in importance. For example, at 3.75-kw demand per consumer, these factors account for about six times what they do at 500-watt demand per consumer.

NETWORK PROTECTORS

One of the valuable and modern implements that have been produced for distribution work is the network protector. Its original application was to high-load-density commercial areas. During the depression, light-duty network protectors became available but so far have had very limited application. Here, however, is a tool that makes small secondary networks practical in the small commercial areas that occur in small towns, and at various locations in larger cities. The trend towards decentralization in our cities should greatly increase its application usefulness.

Along with the protector goes the modern pre-assembled aerial cable. Many of the types of areas mentioned do not require underground construction. However, the use of overhead lines to feed secondary networks is not entirely practical because of their vulnerability, with possible outages, and the need for interlacing the feeders, thereby compelling two or more open-wire circuits to be on the same pole. Modern aerial cable may solve this problem in a practical way at a reasonable cost.

The work that has been done to produce cutout boxes with accurately made fuse links has succeeded in providing low-cost protection for distribution transformers and, when combined with the high-speed reclosure feature, these cutouts give excellent results on branch lines. These tools make possible the lowest circuit costs for very long lines in suburban and rural districts. Along with them, there is now available the choice of several types of automatic reclosers to meet the increasing need for better continuity at reasonable cost. These cutouts and reclosers also help in making available the economies of 13.2-kv distribution in urban areas.

The time-current characteristics of power fuses have been made so dependable that the economies of "banking" are now practical, and as a result the practice of banking will grow to take its justifiable place in power distribution. It is particularly applicable where there is a substantial diversity like short-time electric-range peaks and motor starting currents. Already, large investments are being made in secondary systems to prevent voltage fluctuations caused by motor starting currents. Some think it is also essential to maintain voltage for peak loads of as short duration as five-minute peaks of cooking ranges, with the thought that otherwise the speed of cooking suffers. Banking is a "natural" for these problems in systems.

The insulation level of distribution equipment has been very carefully studied during the past few years

CAPACITORS
the quick, low-cost way to...
release utility system capacity
increase electrical capacity of
10 to 40%

How capacitors can be used by utilities to release system capacity and by industries to reduce power costs is illustrated by this exhibit on the MPA Special. Pictorially represented case histories show the actual dollar savings made possible by the use of capacitors.

and made to conform to modern knowledge obtained from extensive laboratory and field studies of lightning. Also, both valve and expulsion types of arresters of various designs and costs are now made available to fit the level of protection desired.

UNIT SUBSTATIONS

The unit substation is the most far-reaching tool of comparatively recent development, and it is now being utilized more and more widely. It is not only of lower cost than equivalent apparatus installed but it provides a practical way of providing substation supply to primary systems at the time and the place the load occurs. Its use permits, where applicable, the development of a primary network system which gives the highest order of continuity and the most uniform voltage conditions on the primary system. This type of substation as developed in its simplest form is bus regulated, so that its size corresponds to the economic loading of a primary circuit for existing conditions.

Unit substations are not limited to that application, however, because modifications are available to the distribution engineer that will enable him to design economically for specific situations by using the "building-block" approach to form the economic substation size. This building-block approach is now applicable to most every situation encountered, even those where single-phase feeder regulators are necessary or subtransmission substations are supplied at voltages high enough to require outdoor steel structures.

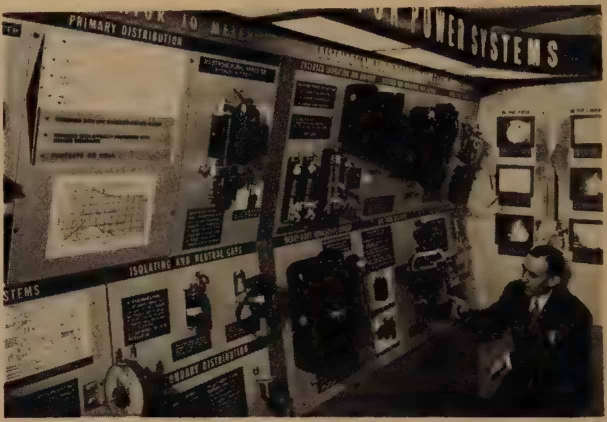
All those benefits of package equipment extend also to industrial utilization, thus making possible the now widely accepted load-center distribution system.

In addition to the bus-regulated unit substation, the pole-type regulator has been developed because it was recognized that many areas would have long branches radiating from the principal load area. If bus regulation were relied on entirely, there would not be adequate voltage for these branches, or the load per circuit would have to be reduced. Pole-type regulators are very flexible in their application and can be used in series on long suburban and rural lines to keep the voltage drop between the first transformer and the last transformer within allowable limits. In this way, more load can be carried over a given amount of copper or circuit.

SHUNT CAPACITORS

Another useful tool that is coming into its own is the shunt capacitor. These capacitors reduce current and raise voltage at the same time. Sometimes, they are applied to reduce current by supplying the kilovars demanded by the load. At other times they are applied just to raise the voltage by the effect of their leading current flowing through the system reactance. When applied for either or both purposes, means are available for switching them in or out in appropriate increments if some voltage control is desirable or necessary. For primary circuits covering low-load-density areas or long lines or branches, these shunt capacitors can be effectively used to raise the voltage between the first and last transformers, thus enabling this higher-cost type of equipment to carry more revenue-producing kilowatts. Of special note is the fact that they have recently been made available at a cost that extends their usefulness to the secondary system and thereby increases that system's load carrying ability.

For neutralization of line reactance to eliminate disturbing voltage pulsations caused by certain kinds of load, series capacitors have been developed; but as yet their application has been limited by the cost of protective equipment.



A cutaway model of a distribution oil fuse cutout is examined by a G-E executive. Many other examples of distribution system protective equipment are aboard.

The development of photocell and phototube devices has provided a solution to an economic control problem in street lighting. Such a device, together with suitable relays, is useful in developing multiple street lighting systems in many areas. The installation of a self-contained photo control in each multiple lamp makes low-cost street lighting possible in many isolated or segregated areas. All that is needed is to mount the lighting fixture and then connect it to the secondary supply system.

Carrier-current control and time switches have proved to be reliable means for controlling off-peak loads such as water heaters.

New insulations have been developed for cables to increase current-carrying capacity, save the cost of lead, and solve termination problems, thus reducing the cost of underground installations. Many combinations are available to meet a variety of conditions. Oil-filled and gas-filled cables, either in ducts or pipes, pave the way for high-load-density service in urban areas. These make it possible to hold to reasonable cost the investment in high-voltage transmission in those areas.

With the developments that have been referred to in this brief article, it is evident that distribution-system economics does not now lack adequate tools. To be sure, there are new things to come and a few things are still to be desired, but we are already well equipped to fulfill the demands of today and tomorrow.

The technical
and economic
significance of
developments
and trends in . . .

MOTOR DRIVES IN INDUSTRY

By L. A. UMANSKY
Industrial Engineering Divisions, Apparatus Department
General Electric Company

INDUSTRY is currently using about 55 percent of the total electric power produced in the United States. In 1948 this use amounted to 170.6 billion kw-hr. About 75 to 80 percent of that amount is used by motors; the balance is utilized by electric furnaces, electrochemical applications, and lighting.

It is estimated that about 100,000,000 hp of motors is installed in industrial applications. This total does not include the additional horsepower of the many millions of fractional-horsepower motors used in appliances, nor that of the fast-growing number of motors used on farms and for air conditioning and for elevators in city buildings.

Since there are close to 12,000,000 production workers in our industry, each of them has available about 8 hp of motor power. Because the muscle power of a man is scarcely more than 1/10 hp, the available motors multiply the power of an average American industrial worker some eighty-fold. This large amount of power per worker is one of the secrets of productivity of our industry.

In a similar fashion the many millions of motors in the nonindustrial field relieve the farmer from many of his chores, and bring ease, comfort, and efficiency into our homes, business offices, and public buildings.

While the motors replace and multiply the muscle power of man, the spreading use of automatic control in many instances extends man's intelligence. Many a task performed by this type of control could not be done manually as well, or at all. A skillfully laid out control brings out to the best advantage the built-in motor characteristics. Thus, a good motor and a good control are expertly blended to provide the best possible motor drive.

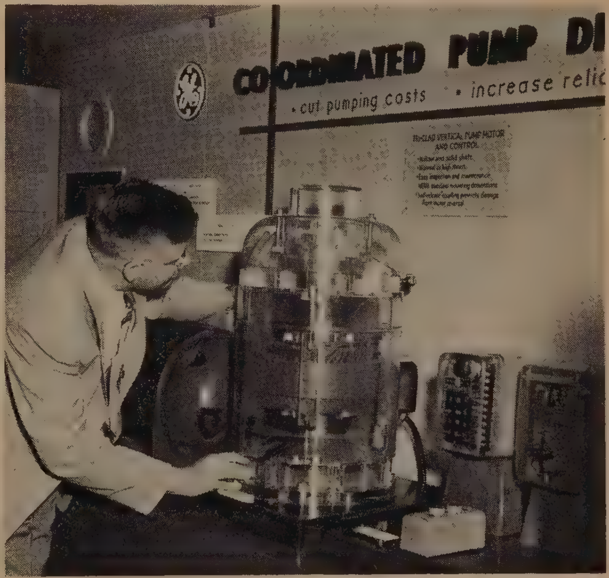
MOTORS ARE AVAILABLE FOR ALL REQUIREMENTS

All motors have some traits in common: They convert electric power into mechanical power with a high degree of efficiency—as high as 98 percent in some cases; and they have a minimum of wearing parts—usually just two bearings—hence their maintenance is negligible as compared with that for other sources of motive power. However, the types and sizes of motors and the means of controlling them vary greatly, so much in fact as to provide a ready, but not always obvious, choice for almost any application.

First of all, motors have been developed in capacities which range from that of the motor in an electric clock to a 65,000-hp motor for driving an irrigation pump at Grand Coulee, or for a wind-tunnel drive requiring 87,000 hp. They vary also in speed: some run at constant speed while others cover a widely adjustable speed range. They differ in method of starting. Their types of enclosure vary greatly. Furthermore, their differences extend to such characteristics as voltage and frequency of power supply, etc. It is the development of motors and control with such different features that has made motor drive adaptable to different tasks to be performed and to varying conditions of operation.

CONSTANT-SPEED DRIVES

A large majority of today's motor applications, probably 75 to 80 percent of the total, call for constant-speed drives. The average capacity of industrial motors is only 7.5 hp, or slightly less. For capacities less than, say, 100 hp, and for constant speed, the squirrel-cage induction motor provides the most economical drive, by a wide margin. Its simplicity and sturdiness have made it, by far, the most popular choice.



The mechanism of this vertical pump motor and magnetic control can be observed through the plastic cases. Visitors to the MPA Special can start and stop the motor.

It is not surprising to note at this time that constant speed has satisfied many of our requirements. There is no end to single-purpose motor applications. A pump is installed to deliver a certain volume of water, or oil, against a fixed head; if the demand varies a simple and inexpensive on-off control is often sufficient, or if the installation includes several constant-speed pumps, the total flow can be readily controlled by changing the number of pumps in operation. A loom shed in a large textile mill may include several thousand looms. Not all of them may be doing the same kind of work or running at the same speed; but each loom may run at one speed for a long time and, when a speed change is called for, it can be obtained readily and economically by changing gears, still retaining the use of the constant-speed induction motor.

It is because these and other similar applications are numbered in millions, that constant-speed drives—particularly with squirrel-cage motors—are in such large majority.

Another and related observation is that the growth of our power systems usually permits the simplest, full-voltage starting of a-c motors. The use of wound-rotor motors, *for the sake of starting conditions alone*, so prevalent a generation ago, is now not often required. To be sure, wound-rotor motors are widely employed when necessary to suit drive requirements (rather than power-system limitations), as for instance for cranes and hoists, many conveyors, and other machinery which need a gradual start and some degree of speed control.

Synchronous motors have won for themselves a legitimate place in the constant-speed field. Their good power factor, adaptability and low cost for low-speed applications, large air gap, and general sturdiness have made synchronous motors the first choice for such medium and large capacity drives as reciprocating compressors, ball mills, crushers in cement and mining industries, rolling mills, etc. The designers' skill has increased the ratio of starting current to the extent that now the starting of synchronous-motor drives is no longer a problem.

In a class by themselves are the developments to meet applications requiring higher speed than the 3600 rpm obtainable from a 60-cycle supply. Woodworking tools, machines for inside grinding of small holes, and some others, call for motor speeds from 10,000 rpm to as high as 120,000 rpm. Portable tools also require high-speed motors for the sake of weight reduction. For these applications squirrel-cage motors are used, supplied from frequency changers that provide 180- to about 2000-cycle power.

THE TREND IS TOWARD ADJUSTABLE SPEED

There is a definite trend toward greater use of adjustable speed in industry. Even though an adjustable-speed drive is more costly than a constant-speed drive, the trend toward the former is economically sound and, if anything, will keep on growing. There are several factors contributing to this trend.

In the first place, many a machine tool, rolling mill, paper machine, or other machinery can be used on a greater variety of products, each requiring different processing speed, if the motor drive is of an adjustable-speed type. Thus, the versatility of the production tool and its economic worth are enhanced. One such tool can replace two or more single-purpose tools. The over-all plant investment is reduced in spite of the greater cost of the electric equipment.

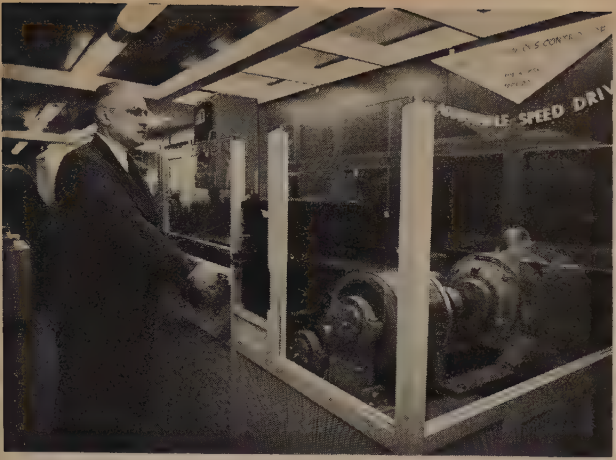
Secondly, industry is changing over to continuous processing at an accelerated rate. Several processing machines are so arranged that the product passes in succession from one machine to the next. A tandem strip-rolling mill, a rubber calender train, and a textile finishing range are typical examples. The product may pass through the several machines as a continuous flow of material in the form of a web or other cross-section. The work done by each machine is changed from time to time, depending on the product which is processed. It then becomes necessary to readjust the relative speeds of the several machines, in addition to changing the over-all processing speed. Separate adjustable-speed drives for each machine become a necessity.

In many instances, even for noncontinuous operations, several drives are employed on a single machine. This practice is growing in popularity, particularly with many modern machine tools. For instance, one large planer-miller has 16 motor drives, nine of which are of adjustable-speed type, thereby making possible the individual adjustment of each motion to the requirements of the specific work to be done. These adjustable-speed drives include: a 100-hp planer-table drive, a 15-hp milling-table drive, a 30-hp rail drive, two 5-hp cross-feed drives, two 2-hp quill and ram adjustment drives, and two 50-hp spindle-head drives. The adjustable-speed feature of these drives greatly increases the versatility of the machine. Also, the use of separate motors for each motion greatly simplifies the mechanical design and reduces the maintenance of this machine tool.

ADJUSTABLE-SPEED DRIVES

Electrical engineers have worked for more than half a century on the development of ways to control motor speed. Due to the prevalence of a-c power distribution much effort has been spent on developing a-c adjustable-speed motors, and it has not been fruitless. For example, in small sizes, say up to 75 or 100 hp, a brush-shifting a-c commutator motor (like the General Electric Type ACA) gives an excellent account of itself in certain applications. It is a self-contained machine; i.e. the driving power and the speed control means are built-in in one unit which operates directly from a-c power supply. It is particularly well suited to single-drive machines.

However, for the majority of continuous-processing machines, with several drives operating in tandem, experience still shows that the most flexible and economical drive consists of d-c motors supplied with adjustable voltage from one or more motor-generators. This system is by no means new, having been in use for better than 50 years, but present-day refinements in control have made this system particularly attractive for the exacting requirements of modern industry. It provides a combination of very useful features: a very wide range of speed; maintenance of proper speed



K. H. Runkle, manager of the G-E Industrial Divisions, operates the model steel-mill exhibit in which tension, direction of rotation, and speed of the strip may be controlled, pinholes are detected, and thickness is measured.

relationship between several drives, which however can be readjusted from time to time; accurately controlled very low or "threading" speed; quick stopping by means of regenerative braking; and easy reversing. It is for these reasons that this system is steadily gaining in popularity. Suitable equipments in small and medium sizes (up to 60 hp and even 200 hp) are now available in package form whereby the motor-generator and suitable control are factory assembled in a steel cabinet. In this or other forms the system is used in practically every branch of industry, both for tandem drives and for single-drive machines. High-speed elevators, paper machines, metal-rolling mills, and a thousand and one other applications are employing this system. The applications range from drives of 1 hp on a machine tool to 10,000 hp on a reversing blooming mill.

That system fits well into the modern concept of a-c power distribution; a-c is carried through the plant; conversion to d-c is done when necessary at the points of utilization. Another variation of substantially the same system is the combination of d-c motors with rectifiers; i.e. with electronic means of converting a-c to d-c. By controlling the rectifier voltage and the motor field, the same wide speed range is obtainable as with motor-generators for the d-c source. Precision control is readily available. Small drives, up to about 30 hp, employ thyratron tubes and are known under several trademark names, such as Thy-mo-trol*. For larger sizes, mercury-pool tubes (ignitron tubes) are used. Many drives of these types have been applied in industry—from fractional horsepower for small machine tools, to 100–200 hp for printing presses, to 15,000–18,000 hp for steel mills.

D-c motors operating from constant-potential d-c supply are still being used very widely and successfully in industry. In fact, their number greatly exceeds that of the adjustable-voltage d-c drives. Motor-field control can readily give a 4:1 speed range to a constant-potential motor: wider speed ranges, like 6:1 and even 8:1 are feasible. These d-c drives and their control have excellent characteristics; while not as flexible perhaps as the adjustable-voltage systems they are better than anything offered for this purpose in the a-c motor line. For converting a-c to d-c supply for these motors, either motor-generators or rectifiers are employed. In any particular installation the choice between constant-potential and adjustable-voltage d-c drives is usually settled by the balance between economics and expected performance.

Several adjustable-speed a-c drives, known by the names of their inventors as Kraemer, Scherbius, and Clymer, are useful for special applications, usually those requiring equipments of large size. They all employ a wound-rotor induction motor as the main driving unit, and control its speed by supplying adjustable frequency to its rotor winding. For instance, a 60,000-hp Clymer drive is now being built for a supersonic wind tunnel.

Thus, there is available a large variety of adjustable-speed equipments. With so many different systems to choose from, the application engineering skill consists largely of making the right choice for each specific case.

SPECIAL MECHANICAL FEATURES

Electrical engineers have also developed many special mechanical features of motor design to suit different applications.

The general trend is toward greater protection of motor windings from external damage, i.e., toward more complete motor enclosure. The standard induction motor now available is dripproof; the so-called open design that was prevalent less than ten years ago is now considered obsolete except in special cases. A still greater degree of enclosure has been produced in many forms for use where conditions warrant it. For outdoor or dirty locations, or where fumes and dust prevail, totally enclosed motors are essential and may be procured with or without external ventilation features, depending on size. For use in hazardous locations there are the explosion-proof motors. Finally, sleeve, ball, and roller bearings are available for applications requiring them.

Here, again, the multiplicity of available motor forms demonstrates not only the electrical engineer's knowledge of the different need for motors and control but also his ability to serve well the whole gamut of these needs.

BETTER PERFORMANCE AND LONGER LIFE

Superior magnetic steel and insulation, better knowledge of ventilation and heat transfer, and greater designing skill in general enable the engineers to utilize to far better advantage the active materials in an electric machine. For instance, an up-to-date 40-hp induction motor is built in the same frame size which could accommodate only 7½ hp rating in 1900. This is accomplished with the same temperature rise and with far superior performance characteristics. While a number of 50-year-old motors are still in service, the average life expectancy of the 1950 motor is definitely higher than that of its 1900 counterpart.

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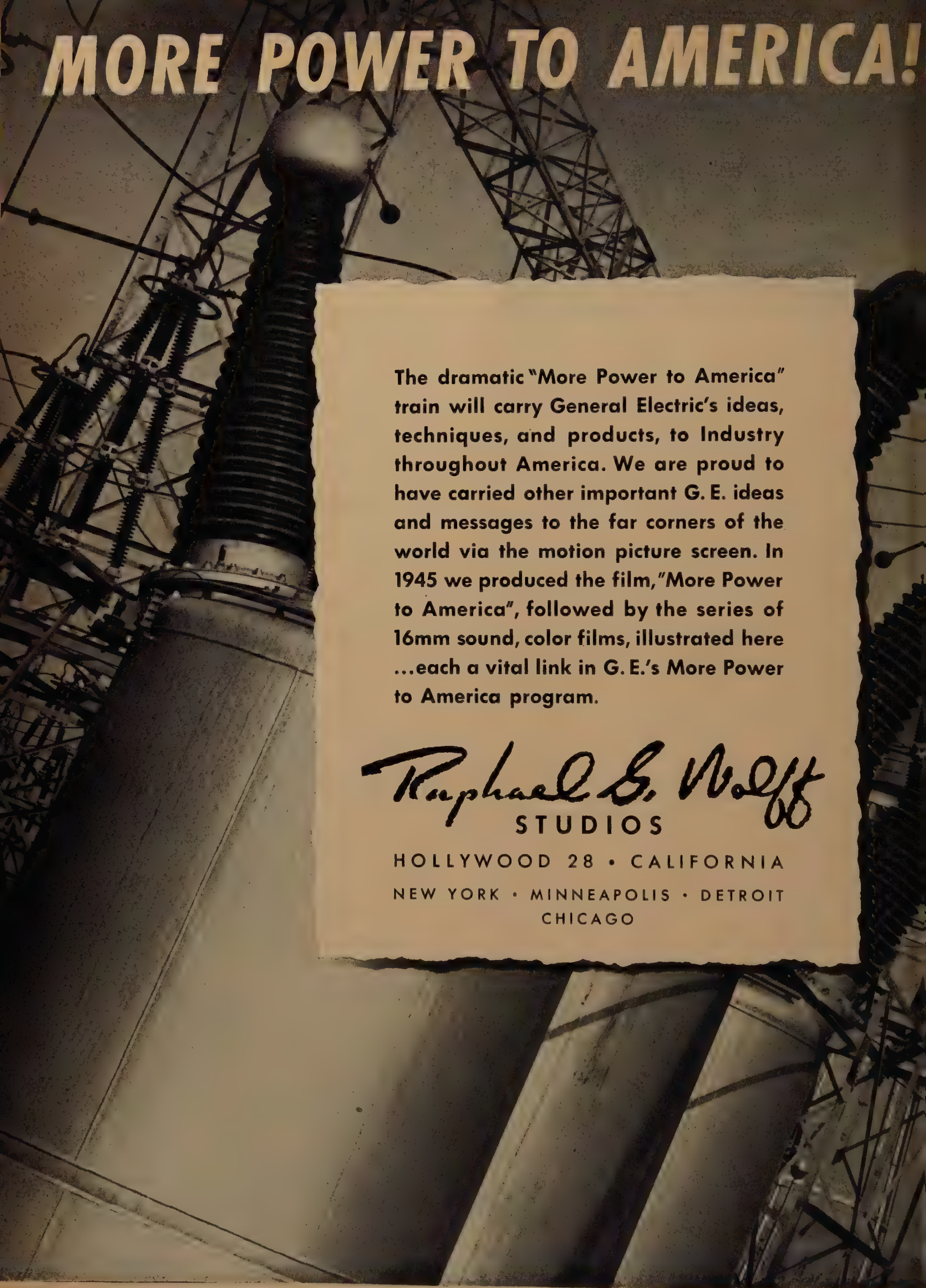
*Registered in U.S. Patent Office by the General Electric Company.

MORE POWER TO AMERICA!



The dramatic "More Power to America" train will carry General Electric's ideas, techniques, and products, to Industry throughout America. We are proud to have carried other important G. E. ideas and messages to the far corners of the world via the motion picture screen. In 1945 we produced the film, "More Power to America", followed by the series of 16mm sound, color films, illustrated here ...each a vital link in G. E.'s More Power to America program.

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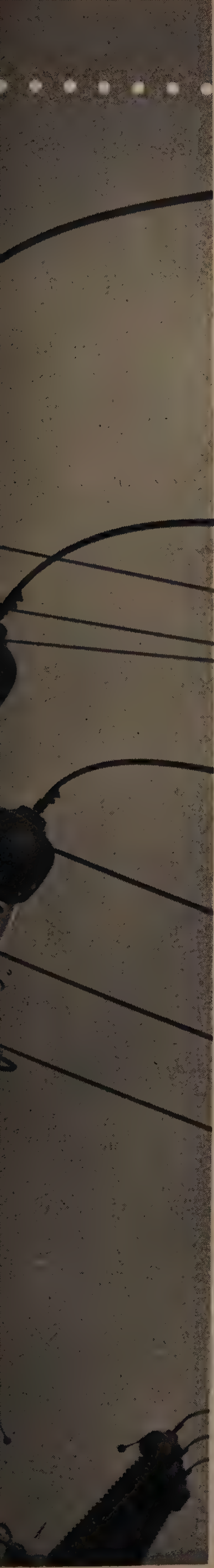
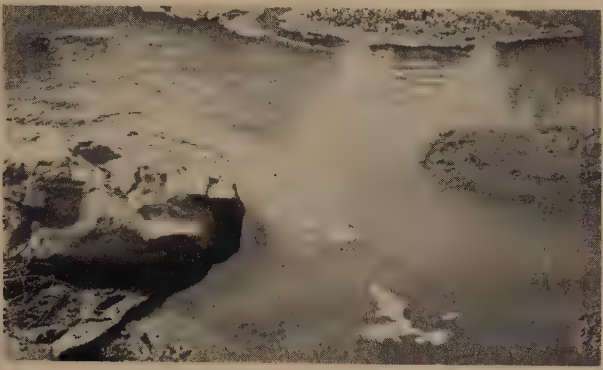


"More Power to the American Farmer"



"Clean Waters"

"Arc Welding at Work"

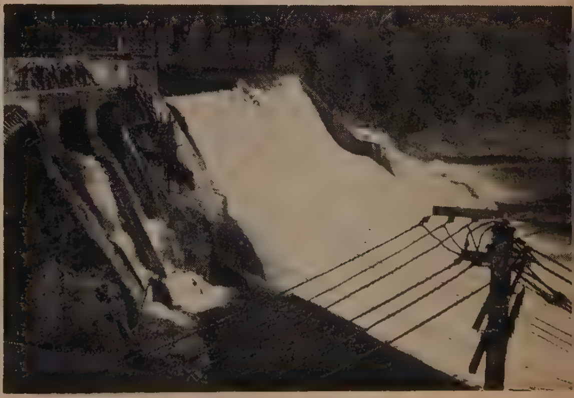
"Textiles Unlimited"

"Life Stream of the City"

"Lease on the Future"

"Running Water on the Farm"

"This is Resistance Welding"



"Water" (now in production)

The technical
and economic
significance of
developments
and trends in . . .

MATERIALS HANDLING

WHEN the pyramids were built, the ancient Egyptians used the only method of materials handling known to them—manpower. History indicates that the only machine help they had was the inclined plane.

Until just a few years ago methods had not changed a great deal. Our railroads were built with muscle power, either human or animal. Our factories were not equipped with cranes for anything but the heaviest loads. Such things as fork trucks and conveyor systems have only recently come into widespread use. The advent of the diesel-electric gave added impetus to the use of switchers within industrial plants.

But well planned, highly efficient handling of materials has been a large factor in making America great today. It is one of the potent answers for the ability to achieve the tremendous production of goods for which this country is noted.

Highly mechanized, motorized systems have meant more power to the individual worker to do a better job, with less physical effort and at lower cost.

GENERAL MATERIALS HANDLING

By C. P. HAMILTON

Industrial Engineering Divisions, Apparatus Department
General Electric Company

TODAY, when a factory is planned or material is to be moved, careful attention is given to the problem of moving parts or material to achieve the desired performance at a minimum cost.

MATERIAL HANDLING IN THE FACTORY

The scope of the materials-handling problem is generally of about the same complexity as that of the product being built. If such an item as a shaft or a casting for one machine is involved, a simple hoist or truck may be sufficient. On the other hand, if the project is the manufacture of steam turbines, movement of many parts, both small and heavy, is required.

In the planning of the new G-E turbine building, the flow of materials and aisle space were so designed that a total of 58 battery-operated type of fork trucks could be effectively used, in conjunction with numerous small hoists and several overhead cranes, up to 200 tons capacity, and with extremely fine control.

For producing other items, such as refrigerators, a conveyor system can transport a large portion of the parts efficiently. Whether the movement is from one spot to another on a floor, between floors, or even a considerable distance between buildings, conveyors can do the job. In some instances, a continuously circulating conveyor system is used both for transportation and to store parts temporarily until needed in production.

Three general types of electrically operated crane hoists are in common use. The single-purpose hoist provides an effective method of handling material when used with a particular machine within a relatively short radius. For example, a small hoist with push-button control enables a heavy piece to be positioned for machining quickly and almost effortlessly.

If two or more directions of movement are required, over a limited area, the floor-operated overhead crane provides a convenient means to handle material with a minimum of restriction to the production space.

Visitors to this exhibit on the MPA Special get the impression of standing in a crane cab, looking down into a factory. This type crane provides highest speed and accuracy when heavy pieces are to be moved.

When material is to be transported in fixed bays, from one area to another, or when heavy pieces are to be moved, the cab-operated overhead crane provides the highest speed and accuracy for positioning loads.

The electric truck, with its elevating means and innumerable adaptations for picking up loads, has become one of the most versatile and widely used material-handling tools for factory and warehouse uses. The operation of the battery truck is unrestricted in direction of movement—indoors or outdoors. Its quietness of operation and the absence of fumes make it well adaptable for use in closed areas.

Since the benefits of palletizing loads of similar materials for shipment or for movement through factory areas have become more generally known, the use of the fork truck has greatly expanded. As an example of the possible saving by this method, one manufacturer reduced the cost of handling induction-motor castings several thousand dollars per year through palletizing the castings for shipment from the foundry.

HANDLING FREE-FLOWING BULK MATERIALS

In many of our large construction projects, enormous quantities of earth must be moved and even larger amounts of concrete poured. To move this material in sufficient quantities at minimum cost is a handling problem of the first magnitude. When thousands of tons per day are handled, cost-reduction studies can pay off handsomely for the user.

ELECTRIFIED CONVEYOR DRIVES
for every plant need
Engineered applications for coordinated systems
Motors and control built for the job
conveyor
synchronization
your problem

This working model of an electrically operated conveyor drive demonstrates the smoothness with which materials can be moved with this type of equipment and points out the importance of using co-ordinated, engineered systems. The conveyor's speed can be controlled by push buttons.

Normally, a number of successful materials-handling methods are applicable. In dam construction, for example, either large gantry cranes or cableways can be used to place cement. In either case the modern system of adjustable-voltage d-c control provides a means of obtaining fast, precise load handling that is reliable.

The cableway installation for the Pine Flat Dam on the Kings River in central California, with a separate hoist and trolley drive, each using amplidyne-controlled d-c motors, will hoist an 8 cubic yard bucket at 450 fpm and traverse at 1800 fpm.

Lately, conveyors have often replaced trucks for long-distance transportation of bulk material. A four-mile conveyor was used at the San Jose (Cal.) dam, and a ten-mile system was installed for the recently dedicated Shasta Dam. A proposed system, about 102 miles long, will carry iron ore one direction and coal the other.

Perhaps the most spectacular of materials-handling machinery is the mammoth lift and turnover car dumper for emptying railroad cars into steamers. Electricity has largely replaced steam for this job to permit dumping 55-ton cars at a rate of 70 per hour. The dumper at Sandusky (Ohio) dumped 1,044,344 tons of coal from 17,160 cars in one month without interruption.

To permit maximum utility of the ships and railroad cars, vessels must also be unloaded quickly. A ship can now be unloaded in four hours with four electrically operated ore bridges equipped with 11 cubic yard buckets. Projected bridges will have 20 cubic yard buckets and use adjustable-voltage d-c for the hoist and trolley drives. High-voltage a-c for the motor-generator sets will be fed directly to the bridge structure by current collector systems on these newer types.

Obtaining raw materials by surface excavation is a simple problem for the electrically operated shovel and drag-line scraper, particularly where large-volume production is needed. In one recent year these machines handled over ten times the total tonnage of the Panama Canal excavation.

EQUIPMENT AVAILABLE FOR ALMOST ANY TASK

Equipment is available for practically any materials-handling problem, regardless of its magnitude or complexity, whether in factories or for bulk handling of coal, iron ore, or other bulk materials.

Modern electric motors of the proper characteristics, and with controlling equipment carefully applied to meet the particular requirements, will furnish the drives to give the best assurance of successful performance.

With the low cost and high production of mechanized materials-handling systems, the pyramids could be built today in only a fraction of the original time.

INDUSTRIAL LOCOMOTIVES

By J. H. WILLIAMS

Locomotive and Car Equipment Divisions, Apparatus Department
General Electric Company

ANY discussion of materials handling in industry today must include the means by which perhaps the largest tonnage of all is moved—the industrial locomotive. Industrial America literally rolls on rails, and were it not for dependable switching and short-haul locomotives, our economy would suffer.

In the average industrial plant, switching movements are relatively short, but the intermittent heavy loads to be handled require high tractive effort. Although most industrial switching is done during the daylight hours of a five-day work week, many plants, such as steel mills, work on a 24-hour, seven-day week basis. But whatever the duty, the ability of the diesel-electric locomotive to render dependable, economical service day in and day out has made it as popular in the field of industrial switching as it is on our railroads.

A few pioneer diesel-electric industrial switchers were placed in service nearly 25 years ago. Their electric equipment and engines were heavy and bulky. Each locomotive involved a new design; hence they took as much as a year to build and cost $1000 per ton at prewar prices. In spite of these handicaps, the high thermal efficiency of the diesel engine and the smooth flexibility of the electric drive suited them admirably for industrial switching. It soon became clear that industry wanted such locomotives if reasonable prices and deliveries could be offered.

In the middle 1930's quantity production of lightweight, high-speed diesel engines was achieved. About the same time, high-speed d-c traction motors for urban transit were perfected. Designers united these two developments to produce today's industrial switcher.

STANDARD DIESEL-ELECTRIC SWITCHERS

First introduced in 1939-40, standard industrial switcher locomotives were greeted with enthusiasm by industry at large. Standardization and assembly-line production cut the price to about $500 per ton, opening a broad new field of application. By building in advance of orders, locomotives could be shipped in only a few weeks. Purchasers of these locomotives were delighted to find that savings in fuel, maintenance, and stand-by costs were often enough to pay for the new locomotive in three to five years.

Today the line of standard switchers includes six models, ranging from 25 to 95 tons, and rated from 150 to 660 hp.

Progress in design and manufacture has produced even better diesel engines and electric transmissions. Much has been learned from some 1500 locomotives placed in service since 1938—many of them at war plants and with the armed forces. Current models reflect this progress, which adapts them even better to playing a consistent part in more efficient production for American industry.

For example a Texas paper mill cut locomotive fuel costs $5000 in the first six months' operation of their 45-ton diesel-electric. In addition, the absence of sparks greatly reduces the danger of fire.

A manufacturer of large machinery reported that availability of a similar locomotive in its first six months had been over 96 percent, and that savings would net more than $11,000 annually.

Three 65-ton locomotives working 'round the clock in a steel mill require only one eight-hour shift every two weeks for inspection and maintenance. Operating costs are half what they were with steam locomotives.

Availability averaging 98 percent for seven years was reported by a large paper company for their 80-ton diesel-electric. In addition it cut steam operating and maintenance costs in half and eliminated cinder and smoke nuisance.

ELECTRIC LOCOMOTIVES

While the diesel-electric locomotive plays the leading role in industrial haulage, it is not alone. Mining, construction work, special assignments in industrial plants, and unusual transportation jobs benefit by the use of electric locomotives of various types.

for
TRY YOUR SKILL - STEP INTO CA

C. H. Lang, vice president in charge of G-E Apparatus marketing, operates the miniature industrial switcher. Mounted in a mock-up of a switcher cab, full-size locomotive controls direct the model's movement.

Storage-battery locomotives range from the 1½-ton "trammer" used in metal mines to larger sizes used in construction work, coal mining, and similar industries. Like the diesel-electric, they are independent of any outside source of power. Other electric mine locomotives are powered from a trolley wire or through a cable.

The absence of exhaust fumes is a definite advantage of electric locomotives in certain applications. Battery and cable-powered locomotives can be made explosion-proof, if necessary.

The improved line of modern electric mine locomotives ranges in size from four to 35 tons, and is furnished for track gages from 18 inches to standard (4 ft 8½ in.). These locomotives have higher operating speeds, better riding and tracking performance, and greater capacity. Added safety features have been incorporated in the design. Dynamic braking is available.

SPECIAL LOCOMOTIVES

Special locomotives have been built for certain applications. Rotary car dumpers require a special "side arm pusher" locomotive fitted with pneumatically controlled arms on either side. Running on a narrow track between two standard tracks and drawing its electricity from a third rail, it pushes cars to the dumper.

Special electric locomotives with elevated operator's cabs are used to transport cars of incandescent coke from the ovens to the quenching pits. They permit the operator to have a clear view into the car, so that he can control the operations accurately.

These various types of locomotives have "stolen the show" in the field of materials handling on rails. Their industry-wide application will be a potent factor in keeping American business at its best.

The technical and economic significance of developments and trends in . . .

ELECTRIC HEAT IN INDUSTRY

By C. L. IPSEN

Industrial Heating Divisions, Apparatus Department
General Electric Company

IF YOU were one of those who enjoyed a vacation in the Poconos, the Ozarks, or any one of another thousand recreation spots throughout these United States the past summer, you were quite likely introduced to more than one phase of electric heat in industry. For example, the burner on your camp stove was probably brazed by electric heat, as well as the folding camp chairs and portable ice box. Furthermore, the tempered edge on your camping axe may have developed its hardness in an electric induction furnace.

This situation is characteristic not only in the fields of camping—it applies to almost every phase of our daily lives where electric heat has come in to make tools more effective by virtue of less weight or better design, yet making them at a lower cost than by previous methods. For example, after several parts of your kitchen range were fashioned by electric heat, the hard enamel finish was probably baked in an electric oven. The same thing quite likely applies to the electric refrigerator in the corner of the same kitchen.

In this exhibit visitors to the MPA Special can see the major applications of "built-in electric heat" using heating cable and Calrod strip, tubular, and cartridge heaters. Each of six major applications—radiant heating and heating of liquids, surfaces, pipelines, process air and soft metals—is fully explained.

Likewise in industry, electric heat is doing countless jobs which we have grown to take for granted. It melts type metal so that your daily newspaper can come out on time. It galvanized the tank on your electric water heater. The connecting links on your auto shock absorbers were electric brazed for lighter weight and yet more sturdy construction. And in another field of construction, electric heat permits three girls to solder 4000 cigarette lighters per hour. It took eighty girls to do the same job in the same length of time before the application of electric heat. This is but one example of the cost-saving role of electric heat in industry today.

Electric heat has progressed steadily since its humble beginning more than 35 years ago. Today it is practically indispensable to industry, effectively fulfilling the need for the cost-reducing, quality-improving methods of manufacture needed at present.

The General Electric Company first started in the electric-heating business more than thirty years ago in Pittsfield (Mass). The first to be manufactured was the small cartridge-type heater which has maintained its popularity even up to this time. Soon after that, a tubular-type heater was developed which has become famous through the years as the Calrod* unit.

ELECTRIC FURNACE APPLICATIONS

Interest in the electric furnace field started about 1914 when the carbon resistance furnace for forging and heat-treating was developed. At the same time, design of air heaters for japanning ovens reached the practical stage. During World War I, the direct-heat furnace using resistance ribbon came into the picture, primarily for the heat-treating of guns and shells.

This was previous to the development of gas-protective atmosphere equipment and, as a consequence, heavy scaling was considered a necessary evil in the heat treatment of metals. With the advent of gas-atmosphere equipment used in tightly constructed furnaces, industrial electric heat treatment was given a boost, for with gas atmosphere the surface condition of heat-treated metals is equal to or even better than prior to treatment.

Many other applications followed, the most popular being that of copper brazing, which, although developed in 1917, gained its popularity in the late 20's. Furnace copper brazing allowed remarkable improvements in design by reducing the cost of manufacturing many products.

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*Registered Trademark of the General Electric Company.

In addition to improved mechanization and progress in atmosphere-control equipment, electric furnaces have been successfully applied to malleable-iron annealing, brazing, sintering, annealing of bar and strip, bright annealing, porcelain enameling, and various other heat-treating applications. The advantages of the use of electric furnaces for heat treatment are many. Chief of these are: ease of application, precision temperature control, uniform distribution of heat, and lack of by-products of combustion. All of these have beneficial influence on quality and uniformity of products, speed of production, and working conditions.

HEATER AND DEVICE APPLICATION

Heaters and devices known over the years as "spot, strip, dip, and fin," and including the famous Calrod heaters, have been the most diversified of all electric heating equipment. Ranging in size from a baby-incubator cartridge heater, smaller than a little finger and rated at six watts, to a 30-in. deep air-duct heater rated 3240 kw, these heaters have solved many problems in industry. Installed in processing equipment they perform six basic heating functions: liquid heating, surface heating, radiant heating, process air heating, metal melting, and pipe heating. The original applications for these heaters many years ago were in the shoe and newspaper industries. Small cartridge heaters were used in automatic shoe machinery, which has continued as a popular application even to this day. Calrod tubular heaters were applied to type-metal melting, back in the early days of heaters and devices, and today few type-metal machines can be found that do not have electric heaters.

Ease of applying heat in precise amounts exactly where needed is a major advantage of this type of heating equipment. The use of these heaters has increased steadily over the years until today those shipped yearly by the manufacturers have an aggregate rating well over a million kilowatts.

INDUCTION AND DIELECTRIC HEATING

The relative newcomer to the electric heating field is that of induction and dielectric heating. In the past ten years, many applications have been found for this equipment. Steel melting, heating of forgings, annealing of large and small parts, brazing and soldering are being done by induction heating. Dielectric heating is being applied to nonconductors, such as foam rubber, wood, plastic pre-forms, cones of yarn, burlap bags, and the like. In most cases, the equipment can be placed in the production line, reducing handling and increasing production. In addition, the result is improved products, reduced cost, and improved working conditions.

ELECTRIC HEATING AIDS INDUSTRY

Today's emphasis in industry is on product improvement, lower cost, increased production, and improved working conditions. Experience during the war years and since has shown that use of electricity has assured these advantages. The future will undoubtedly bring increased use of all types of industrial heating equipment, especially dielectric heating, induction forging, and electric glass melting. Manufacturers are now realizing the advantage of using electric heat in manufacturing process, essentially for the many advantages it assures.

R. M. Cherry, sales manager of the G-E Industrial Heating Divisions, looks on as an exhibit engineer operates high-frequency induction heating equipment aboard the MPA Special. This working exhibit heats to glowing red a model automotive axle.

The technical
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ELECTRIC WELDING

ELECTRIC welding is continuously achieving more widespread use. During the early stages of the art, engineers did not know enough about welding to use it most effectively. Now, however, this method of fabrication is taking over many fields formerly held by other processes.

In countless operations welding is replacing fastening by bolts or rivets; it features prominently in the design of light-weight fabrications to supersede heavy castings; and it is assuring ever-wider use of stainless steel and other light alloys.

Throughout the field, the application and control of electricity is playing an important part. In all forms of arc and resistance welding, electric current supplies the heat. In many instances, electronic control provides the means for improved precision and speed, particularly in automatic processes. Consideration of electric arc welding and electronic control of resistance welding shows significant advances in their development.

ELECTRIC ARC WELDING

By R. C. FREEMAN

Welding Divisions, Apparatus Department
General Electric Company

SELDOM in the evolution of industry has there been developed a tool so powerful, so versatile, and yet so easily used as electric arc welding.

This fiery needle sews steel, copper, aluminum, even silver and gold, to make whatever the designer may create. The man behind the welder's mask has the world's hottest fire at his command. For him, performing "metal magic" is an everyday task.

Early in this century electric arc welding was practically unknown. Even until World War I it was little more than a repair tool of occasional and limited usefulness. The tremendous gains made since that time mark this as one of the most progressive new tools in industry.

But electric arc welding is more than just a method of joining metals—it is an enabling process which offers engineers a completely new philosophy of design. It opens up entire new vistas of readily attainable possibilities for designers. No longer must a design be dictated by the requirements of casting and subsequent machining. Engineering can now be accomplished in terms of most effective end-use.

Whether it is steel for strength, stainless materials for corrosion resistance, copper for heat transfer or electrical conduction, or aluminum or magnesium for light weight, designers can use the material they want, where they want it, and in the necessary thickness.

The importance of the effective use of materials is emphasized by the changing conditions and needs of our industrial system. In the early days of our industrial development, supplies of raw material seemed limitless in comparison with needs. Furthermore, light weight and compactness were seldom major factors in design.

In recent years, however, limitations in our supplies of metal have come in view. At the same time, the rising tempo and cost of transportation calls for lighter weight, greater strength, lower cost, ability to carry greater pay load.

Electric welding is a major factor in solving these difficulties. With effective design through welding, economies essential to long-term national welfare and security will result. And a double blow is struck toward solving transportation problems—not only are welded ships, trains, and planes able to carry greater pay loads, but metal articles being transported are made lighter through the use of welding.

For clearest understanding of electric arc welding and its ever-increasing contributions to the progress of industry, the following three major types should be considered:

(1). Metal arc welding
(2). Atomic-hydrogen welding
(3). Inert-Arc welding.

METAL ARC WELDING

In the metal arc welding process, electric current flows between a metal electrode and the parent metal parts which are to be joined. The developed electric arc supplies fusing heat which melts the edges of the metal parts and the electrode. These blend in a pool of molten metal which cools, hardens, and thus welds the parts together. Usually the welding rod is provided with a coating which is decomposed by the heat of the arc into gases and slag. These protect the cooling metal from the nitrogen and oxygen of the air, which otherwise might cause embrittlement.

During the time that welding has become the backbone of the metal fabricating industry, new features of compactness, simplicity of control, and superior welding arc performance have been developed in welding equipment to make easier use of the process.

Motor-generator sets for d-c welding now weigh only one-fifth as much, cost but one-third as much as 30 years ago. During this time, the useful range has been so expanded that a single modern d-c welder has greater range than the entire line of standard welders of earlier days.

A-c metallic arc welding, powered by specially designed transformers, now provides high electrical efficiency, low maintenance costs, and freedom from the effects of magnetic blow on the welding arc. Newly developed a-c welders have "hot-start" devices for easier arc starting, special arc-stabilizing circuits, lower no-load voltage for still further reduction in power consumption, and silicone insulation for long life and outstanding resistance to moisture and overload conditions.

Arc welding, as done here on an MPA Special car, helps transportation equipment to carry greater pay load because of welding's high-strength, low-weight qualities.

The design of welding electrodes is a science and an art in itself. It is a far cry from the "fence wire" of the 1920's to the modern coated electrodes. These coatings are made to control arc characteristics, slagging, and the metallurgy of the deposited metal. Continuing developments make it possible to make welds with high tensile strength, high impact strength, unusual resistance to wear and corrosion.

The advantages of welding are not restricted to metal working industries. Versatile welders with a wide range of welding currents are particularly useful for maintenance and repair work. Certain models meet the needs of small contractors, while limited input a-c welders are specially adapted for farm use. Welders are one of the few items of general equipment that give improved performance and yet sell at less than 1940 prices.

ATOMIC-HYDROGEN WELDING

In usual practice, an a-c arc is maintained between two adjustable tungsten electrodes independent of the metals to be welded. Hydrogen gas flows down over the arc. The arc temperature of approximately 11,000 F dissociates hydrogen into the atomic form. The recombination of hydrogen atoms into molecules releases large amounts of heat which can be used for performing welding under most difficult conditions. The hydrogen also serves the useful functions of cooling the tungsten electrodes and of protecting both the electrodes and the molten pool from oxidation.

For "impossible" welding jobs, atomic-hydrogen welding is a regular prescription. This method has been outstandingly successful on hard-to-weld metals, very thin sheets, and applications requiring exceptional smoothness and ductility. It is used to repair expensive dies, to weld combustion tubes for jet engines, and for similar jobs where physical and thermal shock and vibration are very severe.

INERT-ARC WELDING

The Inert-Arc welding process has been developed during the past ten years. Although some pioneer work on this process was done more than twenty years ago, the late war and its urgent need for improved fabrication of light metals gave great impetus to this new process.

Either a-c or d-c can be used to power the welding arc between a nonconsuming tungsten electrode and the metal to be welded. A flow of argon or helium over the electrode and molten pool keeps oxygen away from the welding zone. If additional weld metal is required it is furnished by filler rods.

The highly concentrated heat characteristic of this arc makes heat transfer very efficient and minimizes distortion. Since no fluxes are required, cleaning time is virtually eliminated and there is no danger of flux corrosion on metals such as magnesium and aluminum. Welds made with this process are singularly free from oxidation, scaling, porosity, and weld spatter.

Because the Inert-Arc process makes welding of aluminum and magnesium easy and reliable—for the first time—it literally makes practicable lighter and stronger aircraft, trains, and structures of all kinds. And the little cleaning necessary after welding makes Inert-Arc welding particularly desirable for use with stainless steel and the lighter gages of mild steel.

AUTOMATIC WELDING

What the machine tool is to the file and chisel so should automatic welding be to manual welding.

Electric welding, always a powerful tool, has its advantages multiplied when made automatic, not only because work can be done faster and at lower cost but also because it can be done in a more accurately controlled manner.

Although all types of electric arc welding are being done automatically, the great tonnage of weld metal is laid down by the metal arc process. In addition to the regular open arc process, there are processes in which the molten weld metal is shielded by a blanket of gas or solid flux. The submerged melt process using powdered, solid flux has had widespread application. Recently, attention has been again directed to the use of shielding gases in metal arc welding.

Tanks, drums, boilers, and thousands of other metal products of industry are made better and at lower cost by the use of automatic metal arc welding.

Automatic multiple-arc atomic-hydrogen welders produce Inconel tubing for the heating units of electric ranges at speeds of many feet per minute. The welded seam is strong and ductile. It is so smooth that the joint can barely be detected on either the inside or the outside of the tubing.

Automatic Inert-Arc welders make stainless steel barrels, jet-engine components, and many types of aluminum fabrications reliably and at lower cost.

CHALLENGING PROSPECTS LIE AHEAD

In terms of what it has done as an industry, and more in terms of the new fields of opportunity it has opened for other industrial undertakings, electric arc welding is one of our most progressive as well as one of our newest industries.

Whether we judge welding by its short but active history, by its present and past records of aggressive advancement, or by the tremendous opportunities which lie ahead—it is certain that we see an industry which, if not technically in its infancy, is most assuredly in its vigorous youth with challenging prospects ahead.

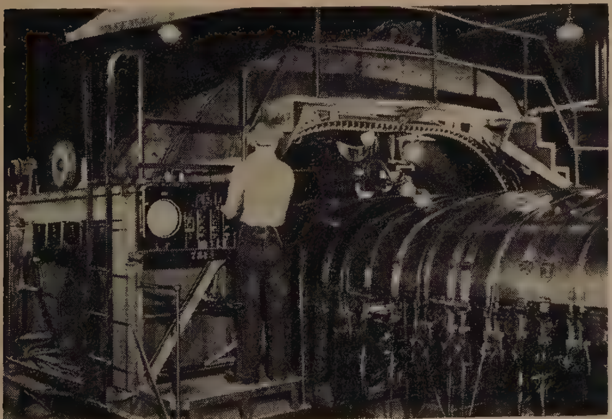
ELECTRONIC CONTROL OF RESISTANCE WELDING

By W. B. HILLS
Control Divisions, Apparatus Department
General Electric Company

ELECTRONIC control has progressively increased both the quality and production rate of resistance welding. Because of the continual advances in the art, almost any metal can now be joined successfully by spot, seam, flash, or projection welding.

Manufacturers who have kept abreast of technical improvements in electronic control have achieved some remarkable savings. One company, using modern automatic control, has increased production 100 percent and cut rejects 75 percent as compared to welding done with an earlier model control.

Basically, the control of a resistance welder determines the time and magnitude of welding current flow and the time and magnitude of pressure on the work. These can vary from a simple "one-shot" application of pressure with a single flow of welding current to highly precise multiple shots of current with varying magnitudes and varying pressures. In the latter way, heat treatment of the spot weld can be accomplished in the welding machine.



Seam welding a car roof at Pullman-Standard with resistance welding electronic controls, as done on the cars of the MPA Special.

When selecting a control, therefore, the type, features, and accuracy needed depend upon the materials to be welded, configurations of the part, and strength requirements of the joint.

Three years ago, the automotive industry was making thousands of spot welds in each car body at a rate of less than 200 welds per minute with existing electronic control. Modern control has helped run actual production speeds up to 450 welds per minute, and makes speeds as high as 600 look feasible.

SLOPE CONTROL

One of the recent developments which has not yet been completely explored by manufacturers is slope control. Tests show that controlling inrush welding current assists greatly in the welding of aluminum.

At the present time, one installation consists of six standard spot welders with slope control being used to weld aluminum to ANW-30 specifications (aircraft). Several of these units are making over 35,000 spots each in eight hours—more than twice the number ordinarily made by most other welders. With the slope control adjusted properly, 800 to 1700 welds can be made without dressing the electrodes, instead of a previous 50 welds or so.

This new control is not designed for aluminum welding alone. Other fields of projection welding and cross-wire welding are finding more uses for slope control.

Today, welding demands from one to several thousand kva can be controlled electronically, to weld fabrications varying in size from radio-tube elements to railroad cars. But even with this great range of sizes and increased production rates, *reliability* of control is becoming more and more the watchword. Circuits providing greater accuracy and more consistent welds are the result of years of design experience.

When necessary, sub-panel assemblies of welder controls can now be changed in a few minutes, instead of hours, through use of new plug connections. Fewer moving parts is another achievement of recent years, which also makes for easier maintenance.

MODERN DESIGNS REDUCE SIZE

Modern designs have cut the size of some control panels in half, reducing floor space required and permitting mounting directly on the welding machine. Factory assembly and interconnection of combinations is also becoming more common.

In situations where the power supply is limited, the frequency converter, which spreads the kva demand on three phases and materially improves the power factor, has lately become quite popular. This equipment has found wide acceptance in aircraft aluminum welding.

Resistance welding has not reached its limit in the manufacture of products. As new alloys are discovered and new methods of fabrication studied, suitable welding techniques will be developed. New electronic controls will make these techniques possible.

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COMPONENTS FOR INDUSTRY

THE many and varied electric components available for a manufacturer to build into his products enable him to reduce the cost, increase the production, and improve the quality of those products. Recent improvements in these components have made them even more useful.

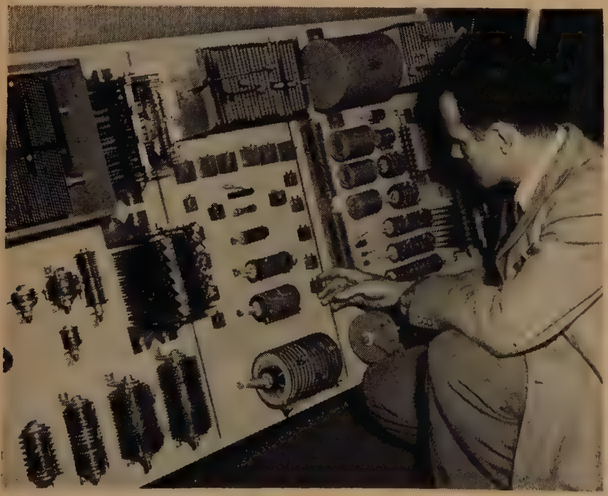
METALLIC RECTIFIERS

By G. C. RUCKEL and I. A. LEE
Lighting and Rectifier Divisions, Apparatus Department
General Electric Company

UNTIL only twenty years ago, metallic rectifiers were used mainly in battery-charging applications. Since that time, more and more uses have been discovered for these devices until today, with the development of huge rectifiers for use in continuous-strip plating lines, they have taken their place beside the largest of electric equipments.

These large rectifiers supply upwards of 200,000 amperes while, on the other extreme, are tiny selenium rectifiers that deliver only 160 trillionths of a kilowatt-hour during their entire operating life.

The only limitation to the size of rectifiers is their relative economy, not the magnitude of the rating. Although the problem has been a challenging one, today it is physically possible to obtain any output desired, paralleling to increase current and connecting in series to increase voltage.



A display of more than 60 copper-oxide, high-voltage selenium, and low-voltage selenium rectifier stacks is being examined by this visitor to the MPA Special. Listed on the same panel are 20 typical applications.

Ever higher voltage ratings per rectifier cell foretell wider use of metallic rectifiers from an economic standpoint. In addition, progress has been made in the design of complete units, including those with built-in air conditioning for steel-mill applications and other oil-immersed and hermetically sealed units for use in corrosive atmospheres.

Continuous research in the development and design of new types of rectifier cells is keeping metallic rectifiers ahead of the challenging number of new applications. So well has this research and development succeeded that in many instances the rectifier actually initiated the development of the device.

Rectifiers can supply d-c power for such electrochemical tasks as battery charging, electroplating, anodizing, and pipeline cathodic protection. In addition, they can furnish direct current to magnets and solenoids in oil-circuit breakers and pinball machines, to milking machines and business machines.

OTHER COMPONENTS

By W. P. SWANSON
Industrial Divisions, Apparatus Department
General Electric Company

FRACTIONAL-HORSEPOWER MOTORS

OVER 30 million fractional-horsepower motors are sold each year. A wide variety of motors is necessary to do today's modern jobs, yet nearly each application requires a motor with some particular characteristics, either electrical or mechanical.

The practicability of a motorized device depends in many cases upon the cost of the motor used. In our economic system, an individual chooses to buy, or not to buy, upon the basis of value received. Therefore, the motor must enable the device to perform satisfactorily and be available at a suitable price.

Today, practically all domestic refrigerators have hermetically sealed motor-compressor units. Commercial refrigeration equipment is rapidly following this trend. Thus the advantages of lower cost, freedom from maintenance, and greater reliability are constantly being emphasized in the refrigeration market.

Ranging in size from 1/12 to 7½ hp, motors for hermetically sealed units are designed to operate continuously in oil and refrigerating gas. They are specially insulated and manufactured to meticulous standards of cleanliness.

H. V. Erben, vice president and general manager of the G.E. Apparatus Department, and J. S. Smith, manager of the Apparatus Advertising and Sales Promotion Divisions, which produced the MPA Special, inspect the display of more than 30 different standard types of fractional-horsepower motors on the train.

Fan motors up to 1/12 hp feature the recently developed unit-bearing design, capable of operating continuously in any position and requiring no subsequent lubrication. Quietness of operation is only one of their outstanding characteristics.

Lightweight champions of the fractional-horsepower motor family are the series motors. Packing exceptional power for their small size, a typical set of ⅓-hp motor parts may weigh as little as 3.1 lb. Designed for lightweight and high power output such as in portable tools, they are built to withstand high-speed operating stresses. Many of these motors are supplied to be built directly into the housing of the manufacturer's product.

MOTOR STARTERS

Strongbox design of the magnet coil is an outstanding feature of the most recently developed line of a-c motor starters. The coil is completely protected by a plastic enclosure and then surrounded with a solventless varnish to protect the windings against moisture, dirt, and mechanical abuse. Tests show that unusually long life can be expected. One of these starters is expected to operate millions of times for an actual life test while on the MPA Special.

Included among the starters available is one with an enclosure having a special gasket material to keep out cutting oils such as are used on machine tools. Other enclosures are explosionproof, water-tight, or dust-tight.

SWITCHGEAR FOR LOW-VOLTAGE CIRCUITS

One of the most important and at the same time most neglected phases of safe power distribution and control is the provision of switching and protective devices which have the ability to safely isolate short-circuited apparatus. Because the short-circuit current which may flow through such a device bears little or no relation to the normal ampere rating of the circuit, low interrupting capacity devices misapplied to a potentially high short-circuit current system constitute a serious hazard.

For low-voltage circuits (600 volts or less), magnetic air circuit breakers provide safe and economical protection and switching for feeders and branch circuits. Available in interrupting ratings from 15,000 to 100,000 amperes and in a wide range of continuous current ratings, they will cover practically all situations encountered in modern power distribution systems.

For lighter circuits, thermal breakers provide adequate switching and protection where available short-circuit current is limited. Designed to fit into standard arrangements of distribution panel boards, they are available in 15,000- and 25,000-amp a-c interrupting ratings.

The high interrupting capacity current-limiting fuse is a newcomer useful on circuits feeding smaller individual power-consuming devices. In contrast to the usually limited interrupting ability of conventional cartridge fuses, these fuses have an interrupting rating of 100,000 amp a-c in all sizes at both 250 and 600 volts. Properly applied, they contribute to the economical elimination of many fire and accident hazards caused by inadequate fuses.

SMALL INDUCTION VOLTAGE REGULATORS

Communications, laboratory, and industrial equipment in the smaller size ranges can now have the same smooth, dependable, and efficient voltage control which, until recently, was possible only in the larger ratings. Available in either automatic or manually controlled designs, these new dry-type induction voltage regulators are built in 300- and 600-volt-amp ratings.

Every type of electric equipment performs best at its rated voltage. A drop of 10 percent of the rated voltage can cause motors to stall or overheat, reduce lamp output to two-thirds, and cut the efficiency of electric ranges to 80 percent. Over-voltage conditions can cause motor torque to damage equipment, reduce lamp life to less than one-third, and similarly reduce the life of heating devices.

These new induction regulators, whether manually controlled for adjustable-voltage sources or automatically controlled for constant-voltage applications, can often save many times their cost by protecting equipment and assuring satisfactory operation.

SPECIALTY TRANSFORMERS AND BALLASTS

The words silent, rugged, and dependable characterize the specialty transformers and ballasts used in countless industrial applications. Quiet in operation and virtually trouble-free, these devices are not always fully appreciated by the user.

Recent developments in aircraft transformers incorporate the use of silicone insulation. A typical 3-kva transformer so insulated weighs only 8 lb, compared to the 26-lb weight of a conventional transformer of the same rating.

To give maximum protection against radio or television interference, the latest oil-burner ignition transformers have both electrostatic and electromagnetic shielding. These shields combine to virtually eliminate return passage of high-frequency impulses from the electric arc in the furnace.

Grouped according to application, more than a score of ballasts for fluorescent lighting are individually pinpointed by indicator lights whenever the lamps with which they can be used are turned on in the exhibit canopy in this display on the MPA Special.

For low-loss control of large amounts of power, such as in theater lighting or heating ovens, the saturable reactor has no peer. It is sturdy, practically free from maintenance, has no moving parts, responds to simple controls, and permits maximum utilization of power. Late improvements to this device include a self-saturating feature which permits tremendous amplification of very small signals in delicate control systems.

Ballasts are equally important partners with fluorescent lamps in achieving efficient, economical, lighting performance. One of the newest ballasts available, the trigger-start type, gives practically instant-starting operation without resorting to the high voltages typical of other instant-starting circuits. It is specially designed to operate the circular fluorescent lamps in domestic fixtures.

SPECIALTY CAPACITORS

New Tantalytic capacitors offer further possibilities in the continuing trend toward ever smaller electronic equipment. Designed for d-c applications where small size and superior performance are the major factors, they occupy as little as 10 percent of the space required by paper capacitors and promise much longer shelf-life than aluminum electrolytic capacitors. Tantalum foil and noncorrosive electrolyte give them greater stability, lower leakage currents and better low-temperature characteristics than conventional electrolytic capacitors.

Permafil capacitors are especially useful in high-temperature applications on d-c circuits. They will operate continuously at ambient temperatures up to 125 C, and will also operate at −55 C.

CAST-GLASS BUSHINGS

The cast-glass bushing is the modern method of obtaining a reliable hermetic seal for liquid- or gas-filled electrical apparatus.

Originally used in communication equipment where severe conditions of humidity and exposure to fungus existed, they have also been found superior for use in power capacitors, filament, rectifier and pulse transformers, and resonant charging reactors. Because the metal flange molded in the bushing can be soldered, brazed, or welded to apparatus covers, glass bushings assure a permanent hermetic seal without special gaskets.

THYRITE*

Made of a dense, mechanically strong silicon-carbide ceramic material, Thyrite has a nonlinear resistance characteristic. Its resistance varies as a power of the applied voltage, but it is stable with respect to time, and substantially independent of polarity or frequency.

During the past 13 years, Thyrite has achieved fame in the field of lightning protective equipment, but it is equally valuable as a protective device in any circuit to limit the voltage surges. Because of its unique resistance properties, when connected as a potentiometer it divides voltage substantially independently of load current.

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OUTDOOR INDUSTRIAL LIGHTING

By D. T. CARTER
Lighting and Rectifier Divisions, Apparatus Department
General Electric Company

A PARADOX exists in the field of industrial lighting! The value of better indoor lighting in industrial plants is an accepted fact—*yet outdoors industry is still operating in the dark.*

Over the past 10 years nearly a billion dollars has been invested in the modernization of indoor lighting. Acceptable levels of illumination for all kinds of work are constantly increasing. But, when the status of outdoor lighting is considered, the picture is still "black."

Let us consider the benefits to management in the general and generous use of outdoor lighting for (a) outdoor work areas within the plant and (b) recreational lighting within the plant for use by employees.

LIGHTING OUTDOOR WORK AREAS

Today, because of the highly competitive market conditions, the goal of all manufacturers is more efficient production and reduced costs. Adequate outdoor lighting can help them meet this goal. Through proper illumination of loading platforms, internal roadways, active storage areas, parking areas, and property lines, expenses can be reduced and dollars saved.

Through the use of planned, up-to-date lighting, comfortable seeing at night for plant employees can be obtained. The result is quicker, more efficient materials handling with less damage to materials and equipment; fewer accidents and less waste; and greater protection from trespassers and thieves.

For example, if we were to trace a piece of steel from the mine to the finished product, we could discover the savings to be effected by good lighting. First, the ore is blown down from the mine face under artificial illumination. It is picked up by huge shovels that are equipped with floodlights. Loading and unloading of the ore boats and trains is an around-the-clock operation, as is the process of steel making. The transportation of the ore to the smelters, of the ingots to the rolling mills, and of the finished steel to the fabricating plants is the business of American railroading, which is universally a 24-hour operation.

The shipment of steel may arrive at the plant spur siding at night. Perhaps it's unloaded and transported to storage after dark—certainly during "short-daylight days" much of it is handled under low-visibility conditions. Like the criminal and the saboteur and the arsonist, who wait for the cover of darkness, so do accident and injury.

Materials handling represents 36 percent of all production costs. As a result, great expenditures have been made in late years for huge conveyorized systems, good loading facilities, and excellent transportation equipment. But how efficient is a conveyor that can be used only during daylight hours? And how safe is a loading platform that is inadequately lighted? And how quickly can electric trucks move in comparative darkness?

When the outdoor working areas are lighted, such places as plant roadways, parking areas, and passageways between buildings should not be overlooked. Roadways should be given the same consideration, as far as lighting equipment is concerned, as modern city streets and thoroughfares. The amount of traffic and the width of the roadway will determine, to a large extent, the type of lighting equipment necessary.

A parking lot is an important part of the modern plant. Fencing protects workers' cars from thievery and helps the guards maintain complete control of entrances and exits to the lot—if there is adequate lighting. And passageways between buildings need to be illuminated for the character of the work and traffic.

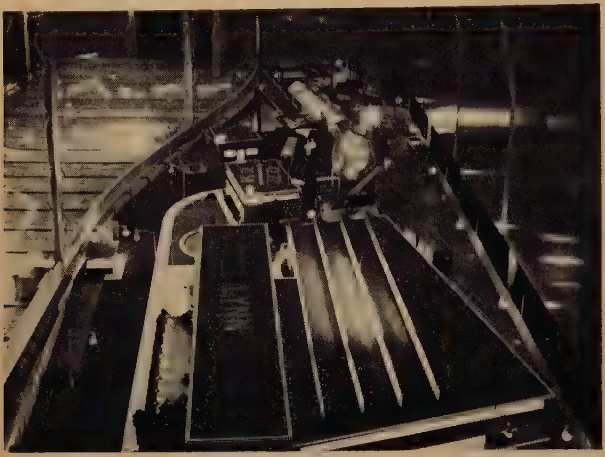
PROPERTY-LINE LIGHTING

Adequate property-line lighting is a primary consideration in the protection of an industrial plant against theft or damage to equipment. As a result, light sources should be so selected and located that the vision of the guards responsible for protecting the property will be aided. This can be done by concealing the guard in comparative darkness and revealing the would-be intruder in full, direct beams of light. If glare is present, it should be directed toward the intruder and screened from the guard responsible for detecting him. The lighted zone should extend far enough on both sides of the property line so that the intruder will be visible for as long a time as possible during his attempted entry.

For safety purposes and to make sure that only properly authorized personnel gain entry, good lighting of authorized entrances is highly desirable. Properly lighted gates make it easy for guards to check credentials and to check material being taken in or out of the plant.

To supplement the general protective illumination around an industrial plant, it is often desirable to provide one or more searchlights which may be mounted on the roof of guard towers and operated from within the tower, either vertically or horizontally. These provide a means of quickly lighting fenced boundaries, waterfronts, and railroad sidings.

With the present high costs of construction, adequate lighting for night work may pay off in handsome over-all savings, to say nothing of the added dividends in reduction of accidents. Several floodlights mounted on fixed poles have been proved superior to temporary systems requiring constant shifting of lamps and wiring. Sometimes, however, it is more practical to use portable light towers mounted on timber skids which can be easily dragged by a truck from place to place.



This realistic, small-scale model of a properly illuminated factory area shows that darkness does not have to interrupt industrial production. A recorded narration explains for visitors to the MPA Special the benefits of each element of a planned outdoor lighting system. Demonstrated are 11 major outdoor lighting applications.

All industrial plants, and large ones in particular, should have portable, heavy-duty lighting equipment available for emergencies. They can be invaluable when a fire or accident occurs. Heavy-duty floodlights with extra-long extension cords or light trucks with a gasoline motor-generator set and several swivel-mounted floodlights will provide an effective buffer against such emergencies.

RECREATIONAL LIGHTING

Most industrial plants, particularly those in smaller towns and cities, are a potent force in the community. In a very real sense, the community revolves around its chief industry. Very often, without effort on the part of industry or its management, there is reflected into the community the progressiveness of the industry—or its lack of progressiveness.

Living as we do in the land of sports-loving people, and living in an era when democracy is being challenged on all sides, it is imperative that we bring all sides together. Experience has shown that there is no more effective way than to participate in athletic programs.

Unfortunately, the capacities of industrial and community recreation facilities are overtaxed in all areas. A partial solution is to floodlight them, thereby easing the burden of accommodation. Twilight and evening are periods of the day when most adults are able to participate in recreation; and floodlighting makes the all-important sports facilities available when most needed.

One of the greatest and more easily recognized values of industrial recreation is from the standpoint of employee relations. Mr. R. B. Davis, General Manager of the Raybestos Company, Bridgeport (Conn.) has expressed his viewpoint as follows:

"The ball diamond, tennis court, or one of the other phases of recreational activity will help your employees forget the mechanical monotony of the shop and recapture the spirit of sportsmanship so fundamental to the American way of life. The elements of co-operative effort, good fellowship, comradeship, and clean living are brought into the shop, office, and home, making a happier, healthier and more productive group. Industrial recreation is a great democratic movement. Men and women in the shop and office, through activity, are lifted out of obscurity into prominence and popularity and will establish their own identity as leaders."

CHOOSING LIGHTING EQUIPMENT

Planning an outdoor lighting system for an industrial plant—whether for working areas, roadways, or for sports—often requires the specialized knowledge of a reputable electrical contractor, lighting equipment manufacturer or distributor. Whether the plant engineer or an outside consultant does the job, however, the procedure is still the same. The first step is to determine the minimum lighting requirements of each area within the plant; then to select the fixtures which best fulfill these requirements.

A wide variety of luminaires, floodlights, both open and closed, and searchlights are available from which to choose those that are most economical to install, operate, and maintain. Whenever possible, it is most economical to select luminaires and floodlights which are heat, dust, water, and corrosion resistant. Of primary importance is the selection of luminaires which have built-in optical assemblies to do the lighting job right. Some produce a symmetrical light distribution; others, through deflectors and refractors, or through combinations, provide asymmetrical distribution.

Consideration should be given to the lighting circuit in any application of outdoor lighting. Underground distribution systems are preferred, with the necessary wiring above the ground carried in conduits or inside the poles. If overhead lines are used, they should be placed as high as possible—and not accessible from pole steps or fence tops. Control equipment may be actuated by push buttons, time switches, or photoelectric relays; but auxiliary manual control should also be provided. Either series or multiple distribution circuits, whichever is most advantageous from an operation and economics point of view, may be used.

The need for lighting exists and the benefits are real—now more than ever before. Comfortable seeing is the criterion on our streets and highways, and it must become ever increasingly the yardstick in outdoor industrial operations. Industry must meet the challenge; industry must come up with well-planned recreation programs and it must make waste and spoilage and injury give way to safety, efficiency, and speed.

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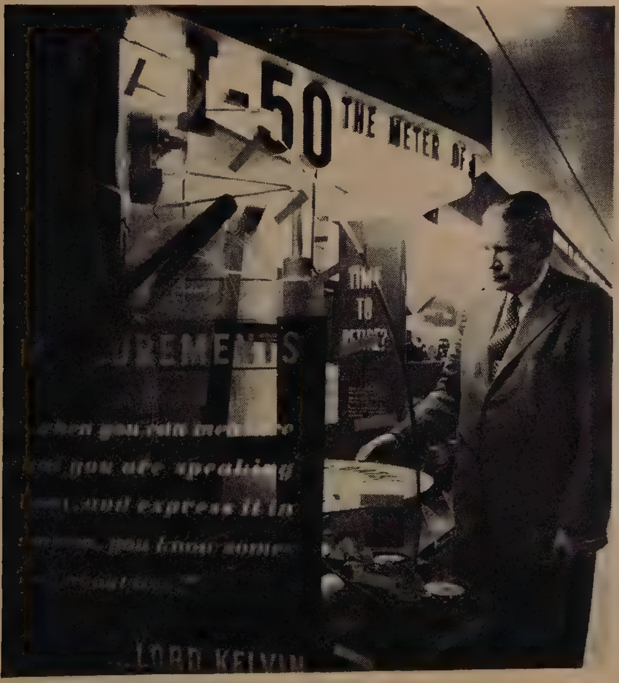
MEASUREMENTS

By I. F. KINNARD and H. C. DICKINSON
Meter and Instrument Engineering Divisions, Apparatus Department
General Electric Company

MEASUREMENT is the focal point of technical progress. The progress that has been taking place in the electrical industry—in fact in all industry—could not have been made without the aid of measuring instruments to extend, to magnify, and to make more precise the human perception that is the basis of all technical knowledge and efficient production.

Behind every product there is a story of men making measurements. Its opening chapters were written generations ago. In these modern times they are being extended: First, laboratory researchers use precision instruments in their intensive and continued study of the operating principles and of the properties of the materials which are the foundation of modern industrial products. Then engineers, with the aid of other measuring devices, combine the results of research into new and improved designs. Testers thoroughly check the first unit, sample, or prototype with a variety of measuring equipment to assure correct performance of the product. Manufacturing personnel make their contribution through their use of still other measuring devices to control processes and factory equipment, and thus make possible a high-quality product.



These immortal words of Lord Kelvin, expressing the significance of measurements, introduce the MPA Special visitor to the Measurements Section of the train.

The measurement story continues with the installation of the product in its assigned job. There, its effective utilization is obtained by appropriately measuring changing conditions, especially when the product is a unit in a co-ordinated operating system. In other applications, service-testing devices are used to give assurance that the product will have a long and trouble-free life. Particularly, when the product is electric energy, its generation, distribution, and consumption must be measured at many points to assure economical operation and fair sharing of its cost. Thus, not only the progress, but also the day-by-day operations of industry depend upon measuring devices.

ADVANCES IN TECHNIQUES AND DEVICES

While measurement is contributing to technical progress and production, advances are being made also in measurement techniques and devices. As the result of continuous studies and developments, new principles are being discovered, and new and improved materials are now being produced, to give better tools to the men who make measurements. The directions of the progress that is producing these modern tools may be classified as follows:

(1). High accuracy over wide ranges of measured values and under adverse conditions
(2). Great dependability with long life and low maintenance
(3). Improved utility in application and convenience in service
(4). Unusual visibility for ease in reading
(5). Neat and compact designs, and attractive appearance.

For a specific consideration of the technical and economic trends and developments in measurement, and of the accomplishments of the men engaged in it, attention will first go to the metering of kilowatt-hours.

WATTHOUR METERS

More than 6 billion kilowatt-hours now generated in this country each week must be measured for efficient operation of electric utilities and for payment. The 45 million watthour meters installed throughout the nation represent an investment of about $500,000,000. Their highly accurate registration for long periods of constant operation under widely varying load and service conditions is essential to correct billing for electric energy. To this end, the watthour meter has been developed into an unusually high-precision product, and its maintenance in service has been a subject of major importance to the electric utilities.

Over the years of engineering development, utilization of new materials and refinement of designs have contributed accurate meter registration over a 1200 to 1 load ratio, compensation for the extreme temperature ranges found out-of-doors throughout the country, and other operating improvements. More recently, major progress has been made to reduce the attention that the meter requires in service. In the past, for example, the jewel bearing supporting the moving disk of the meter was the chief cause of maintenance because bearing stresses of the order of 200,000 lb per sq in. were necessary in minimizing friction torques. In the latest meter design, this major cause of wear is eliminated by magnetically supporting the rotating element. Two concentric cylindrical magnets, the inner one attached to the top of the shaft and the outer to the stationary frame, are magnetized axially with opposite polarities. These magnets, which carry the entire weight of the moving system, are possible only through recent metallurgical progress that has made available high-coercive-force, machinable magnet alloys.

Other advances present in this meter include a combination of damping-magnet design and co-ordinated insulation of the electromagnet to assure maximum freedom from inaccuracies or failures caused by large short-circuits or lightning surges. This added reliability stems from the use of modern materials, alnico V damping magnets imbedded in die-cast aluminum, and electromagnet coils molded in butyl and polyethylene plastic. The meter register, particularly in the cyclometer form, provides greater ease of reading than previously available forms. These and other advantages combined in a highly compact and attractive design make it the first completely new meter in fifty years.

INSTRUMENT TRANSFORMERS

For instrument transformers, another completely new design conception has been made available. These essential though less prominent units of many measurement systems have for years accurately performed their functions of reducing high currents and voltages to measurable and less hazardous values. In the latest dry-type design, however, the conventional insulation of asphalt-impregnated tape has been replaced by molding butyl rubber around the coils and the laminated steel core. This modern material, the result of years of chemical research, assures an extremely long lasting insulation, unaffected by a wide variety of severe operating conditions. The one-piece molded construction gives great strength and a resiliency capable of withstanding shock of high momentary overloads and of rough handling. The arrangement of the copper coils and of the high-permeability low-loss strip-steel core takes full advantage of the new insulating medium to provide increased load range at high accuracy. These factors, resulting from the latest material and design progress, contribute great reliability, long life, and more versatile service to a vital component of measuring equipment.

W. V.O' Brien, G-E commercial vice president and assistant manager of marketing, examines the compass-controlled directional gyroscope. A cockpit-mounted gyro indicator shows changes in compass heading as the model airplane is rotated in azimuth.

INDICATING INSTRUMENTS

Electric indicating instruments are essential to the operation of modern equipment for the generation, distribution, and utilization of electric power. Here, in addition to high accuracy and reliability, the desirable characteristics to which design attention has recently been directed are ease of reading, compact construction, and neat, attractive appearance. Just prior to the war, instruments were first introduced with 250-deg scale arcs. These became practical as the result of radially magnetizing alnico for d-c ammeters and voltmeters, the combining of attraction and repulsion principles in moving-iron a-c ammeters and voltmeters, and the use of a modern ferrodynamic mechanism in wattmeters and frequency meters. These advances made possible an instrument line with scales more than twice as long as in conventional designs. Work to improve scale visibility has, however, continued. One of the latest contributions is a shadow-free design which provides a straightforward solution to the problem of adequate scale illumination. By using a shallow domed cover, in which the scale is placed, uniform illumination is obtained from the general room lighting. Another advance to assist instrument reading at great distances is a new line twice the size of the standard design. This provides scales over 14 in. long—larger than those previously available—together with all of the other benefits of the earlier types.

SERVICE TESTING

Service-testing instruments for preventive maintenance, proper use, and efficient operation of electrical equipment have many additional features not required by the permanently installed types. Typical examples are the hook-on instruments, an improved a-c load visualizer, and a new magnetic oscillograph. In these types, versatility, sturdiness, light weight, and convenient, fast operation reduce the time required for service-testing work.

The outstanding feature of the hook-on volt-ammeter is its ability to measure load currents without disconnecting power leads. This is accomplished by a built-in split-core transformer which clamps around the conductor. With four ranges for alternating currents up to 600 amp, as well as two voltage ranges up to 600 volts, this self-contained 3½-lb instrument combines versatility with suitably high accuracy. The savings both in the testing time and in the uninterrupted operation of the equipment tested have made this instrument unusually popular. A companion to it has just been introduced—a hook-on wattmeter, which is equally convenient and provides six power ranges up to 300 kw and voltages to 600 volts. This variety of ranges, selectable by a single switching operation, is obtained by a novel adaptation of a ferrodynamic mechanism. It utilizes the power lead around which the instrument hook is clamped as the field coil to produce the flux in which the moving coil turns. The advantages of the "hook-on" feature are thus made available for the first time to the important measurement of power.

The A-c Load Visualizer

Values of voltage, current, power, reactive power and power factor in single-phase and balanced polyphase circuits obtained by reading one instrument indicate the versatility of the a-c load visualizer. Either conventional connections can be made to this instrument or the "hook-on" feature can be obtained by using a separate split-core transformer which also extends the range from a self-contained maximum of 50 amp up to 1000. Four ranges for line current and three for voltage up to 600 volts are provided directly by suitable connections and switching. Either the active or the reactive component of the current (depending on the load circuit) can also be read on the instrument. By means of a simple calculator, values of the other component and the power factor can be obtained. From these, the watts and vars may be quickly tabulated. Thus, one five-pound instrument provides for a wide variety of the power measurements required to assure efficient performance of electrically operated machinery.

For more complex testing assignments, a new magnetic oscillograph exemplifies the trend to increased utility and convenience. This oscillograph, weighing only 30 lb, has provision for as many as four galvanometers of a new compact design, utilizing high-strength alnico permanent magnets. Most outstanding, however, is the use of Polaroid-Land film with which finished photographic records of current and voltage wave shapes and their phase relations are obtained in less than a minute without dark-room processing.

NONELECTRICAL QUANTITIES

The application of electrically operated instruments to the measurement of nonelectrical quantities, such as time, temperature, light, and hundreds of others, continues to grow. Electrical operation offers many advantages including great flexibility, high accuracy, increased sensitivity, remote indication, and a high order of dependability. The diversity of applications to all forms of human activity is constantly expanding. In many of these, control as well as measurement functions are performed or initiated to provide automatic operation in a wide variety of fields. For example, time switches measuring time by means of a small synchronous motor are used to control home appliances, poultry-house lighting, street lights, and many industrial operations. In aircraft, precision gyroscopes measure direction and actuate automatic pilots that maintain straight and level flight.

The millivolts produced by thermocouples are used to measure temperature for such widely different applications as the service checking of oven-thermostat calibration in domestic ranges and the efficient operation of jet engines in aircraft. Light measurements made possible by the selenium barrier-layer photovoltaic cell, which changes light energy to electricity, have contributed to improved illumination and to increased effectiveness of photography.

A halogen-compound leak of one ounce in 100 years is the unusual sensitivity of this leak detector.

In industry a continually growing number of specialized measurements are performed electrically. Electric gages indicate dimensional differences of the order of a hundred thousandth of an inch. X-rays measure the thickness of rapidly moving hot-strip steel to within two percent. Leaks amounting to one hundredth of an ounce of gas per year are detected immediately by halogen-type leak testers. Similarly, electrically operated instruments for speed, position, pressure, liquid level, sound, stress and strain, vibration, and countless more, are daily finding wider application and are being improved.

Progress in measurement is fast moving—quickly utilizing new developments in many fields and constantly contributing to all advances made by science. Thus, now as ever, measurement goes forward both giving to and receiving from the technical progress of our age.

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CIVIC IMPROVEMENT

PROGRESSIVE cities, towns, and villages throughout America are becoming increasingly aware of the need for well-rounded, continuing, community-improvement programs. They are wrestling with problems of recreation, juvenile delinquency, health and sanitation, traffic congestion, street and airport safety, smoke abatement, and stream pollution. Enlisting the aid of technical experts, they are analyzing their needs, exploring areas of greatest opportunity for improvement, blueprinting programs, and translating these programs into action.

Woven inextricably into each of these programs is electric equipment. By its full utilization in those programs, safe, economical, efficient, and clean electric power is helping to provide a healthier, safer, and more comfortable community life for countless millions.

However, in many communities, civic improvement programs are now only in the formative stages; and in still others programs have not yet been launched. Such communities provide a fertile field for utilizing the latest electrical ideas and techniques for better community living.

LIGHTING FOR COMMUNITY RECREATION

By R. J. SWACKHAMER

Lighting and Rectifier Divisions, Apparatus Department
General Electric Company

FUNDS spent for adequate recreational facilities produce many benefits and can be economically justified.

The full achievement of those benefits of planned recreation depends to a great degree upon the times of day the facilities can be utilized. For many persons, particularly workers, nighttime is playtime, hence the need for lighting the play areas. Surveys show that lighted play areas increase the usefulness of the facilities by more than 25 percent. Manufacturers of equipment have recognized this need, as have also the illuminating engineering societies. As a result, there now are standard specifications and equipment to meet every recreational need efficiently and economically.

In school athletic programs—always a big part of community recreation—lighting may spell the financial difference between a successful and an unsuccessful season. Comparisons of high schools which now play their football games Friday nights instead of Saturday afternoons show that night games outdraw afternoon contests by at least two to one, and, in some cases, four or five to one.

Outdoor sports lighting first became practical about twenty years ago. At that time, the equipment used was inadequate because no better was available, and short-cut installation methods were employed. Moreover, the users did not foresee the extent to which night sports would become entrenched in the American way of life.

Since then, those sports have grown rapidly in popularity; manufacturers have made modern, efficient equipment available; and sound engineering practices prevail in the installation.

While, in the earlier days, the emphasis was on economy and expediency, often with little regard for quality, today's accent is on performance, quality, and appearance.

A member of the staff of the MPA Special inspects a display of street-lighting luminaires. Altogether, nine ways to further community progress and development are shown.

Events of the past decade have resulted in a public consciousness of the need for an ever-increasing proportion of recreation time spent in sports. That may be as an active participant in a community program, or as a spectator. But only with adequate lighting can these sports be carried on in evening hours, when the most of us have a "Chance to Play."

When the return in terms of reduced juvenile delinquency, of improved physical and mental health, and of greater safety against accidents is compared to the outlay for supervised recreational facilities for use at all hours, what community can afford to be without planned recreation?

STREET AND AIRPORT LIGHTING

By J. P. RUTHERFOORD
Lighting and Rectifier Divisions, Apparatus Department
General Electric Company

ANY way you look at it, says a prominent city official, "inadequate street lighting costs the taxpayer plenty—in frequent traffic accidents and high insurance rates, in an unfair burden on police and fire departments and hospitals, and, particularly, in lost opportunity for community growth."

Today's congested traffic conditions have brought about more widespread recognition of the benefits which adequate street lighting can bring to a community. The improvement in equipment designs and applications now enable us to realize these benefits to a greater degree than ever before.

Modern street-lighting fixtures are specifically built to accommodate several types of light sources—filament, sodium vapor, mercury vapor, and fluorescent. Present-day luminaires shield the motorist's eye from glare and provide good light distribution on both the street and sidewalks.

Photoelectric relays, carrier-current devices, and time switches can turn the lamps on and off as needed.

The lack of adequate street lighting represents a lost opportunity for community growth because good lighting can make a real contribution to this growth.

Many communities have proved that good lighting in the business district will do much to hold and attract business. A brightly lighted main street invites out-of-town shoppers to look around, encourages merchants to improve their window displays, and builds civic pride. Vacant stores with "For Rent" signs are seldom seen on well-lighted streets. A community with modern street lighting looks inviting to tourists, worthwhile to industry, and like a good place to live to all prospective residents.

A miniature display of a model community recreation center gives civic leaders a measuring stick for rating their own community. The baseball attached to the bat is used to demonstrate impact resistance of the floodlights.

AIRPORT LIGHTING

Airport lighting, designed to help our fast-expanding aviation industry operate around-the-clock, is an art which owes much to studies and developments during the war.

Powerful modern runway lights can penetrate the densest fog, snow, rain, or dust to signal an incoming pilot his plane's position, altitude, attitude, and orientation with respect to the runway so he can make a safe touchdown. These lights usually operate in conjunction with electronic landing aids.

As this modern runway lighting equipment becomes universally applied, airline schedules should become more reliable and less dependent on weather. Air safety is improving rapidly. Correctly designed airport-lighting systems are making a notable contribution toward these objectives.

FLEXIBLE TRAFFIC CONTROL

By W. E. SCHWANHAUSSER
Lighting and Rectifier Divisions, Apparatus Department
General Electric Company

PROBABLY the only traffic signal that is popular with everyone is the signal that is always "Green." Unfortunately, an all-green signal is an impossibility. With modern flexible traffic control, however, large cities and small towns that find themselves burdened with more traffic than they ever anticipated can achieve a large measure of congestion relief.

The volume, speed, and direction of traffic can be predicted with an amazing degree of accuracy. Up until recently, however, varying conditions had to be compromised to an average which, in most cases, was never satisfactory for all conditions.

With the advent of flexible control equipment, it became possible to provide automatic timing for varying conditions of volume, speed, and direction, not only within the day but from day to day during the week.

This new equipment provides three major design features: triple automatic offset, multiple dials, and expansibility. The triple offset permits different timing for morning and night peak conditions as well as an average timing for the remainder of the day. With multiple dials, the traffic engineer can, at will, lengthen the time cycle or change the proportion of time allotted to each interval. With expansibility an inherent feature, future additions to traffic, or more complex conditions, can quickly and easily be brought under control.

The current concept of traffic control is of "Stop" lights. With flexible control equipment, however, many of the "Stop" lights will, in effect, become "Go" lights, for the equipment, when properly set, will move the largest number of vehicles in the shortest possible period of time.

Furthermore, where serious pedestrian or vehicle hazards exist, modern control, together with adequate signalization, can provide the motorist and pedestrian with greater safety. After all, the only real justification for traffic signals and control is to expedite traffic with maximum safety.

WATER SUPPLY AND SEWAGE TREATMENT

By H. V. CRAWFORD
Industrial Engineering Divisions, Apparatus Department
General Electric Company

TO MOST city-dwelling Americans, the water that gushes from kitchen and bathroom taps is taken completely for granted. Few realize the enormity of the job of supplying abundant clean water to the cities and towns of the nation. Almost none knows that our city water supply systems, in tons of products handled, are seventeen times as big as all the other heavy industries in the country put together.

Through the efforts of water-supply engineers, ample water—all of it pure enough to drink—is today delivered to millions of city homes for less than five cents a ton. No other commodity can be purchased at such a bargain-basement price.

The water industry is not just beginning to electrify; it electrified years ago. But the trend now is to more careful and earlier planning of the electrical systems which go into a new plant. The most modern, reliable, and efficient plants operating today are those in which the electrical engineer was called in the very first day planning started.

A typical high-intensity runway lighting installation is depicted in this three-dimensional mural. Visitors receive the impression of viewing a correctly lighted field from the control tower, and can operate the lights.

In the past, the electrical features—in too many instances—were not given proper consideration at any time, or at least too late to fit them properly into the project. Insufficient space was allowed for inspection and maintenance. In many cases, specifications for electric equipment were so loosely written that inferior equipment could have been furnished, when the highest quality was necessary.

In earlier days, steam-driven pumps were often kept on a stand-by basis at water works, in case of power failure. Due to the great improvement in reliability of electric power, the steam pumps are no longer needed.

Another factor of vital concern is the source of supply. In a large number of instances, the water from those sources is made unfit for human consumption by the discharge of sewage and industrial waste into our streams. Despite our sanitary engineers who cry for more and better sewage-treatment plants, we have continued to pollute our streams until the condition has become a national disgrace. Now, at last, people have become aroused to action, and almost every state has passed, or is passing, legislation for "Clean Waters."

In the many sewage-treatment plants already built, electric equipment has proved indispensable. Electric pumping and treatment equipment does the job efficiently and economically. New control schemes have been devised with completely co-ordinated centers in which all control and metering equipment is located. All this equipment is factory-wired so that the entire control unit is ready to operate as soon as it is moved into place and the incoming and outgoing wires are connected to terminal boards.

SMOKE ABATEMENT

By H. V. NELSON
Industrial Engineering Divisions, Apparatus Department
General Electric Company

THE rapid growth of industry in the last half century with the resulting increase in particles and fumes discharged into the atmosphere, has made it necessary to look to electrical means of preventing the pollution of our air.

In the early days of industry, it was generally accepted that air pollution was a necessary evil. The application of an old principle—electrostatic control of particles—has shown that this pollution can be almost completely eliminated, and has resulted in the development of precipitation equipment capable of removing up to 99 percent or more of the polluting material.

Nuisance abatement may not be the only benefit. In many cases the recovered material is itself valuable, and more than pays for the investment in recovery equipment. In some instances, the material recovered is the main product of the plant. A typical one-day collection in a copper-smelting plant would be 10 tons, and in a cement plant 20 to 30 tons. Electrostatic precipitators are also used to recover valuable catalysts in oil refineries, sodium salts in paper mills, acids and carbon black in chemical plants, and gypsum dust in gypsum plants.

The same principle is used in cleaning air in laboratories, factories, chemical plants, or textile mills where even a small amount of air impurity could cause undesirable results.

An electrostatic precipitator consists of two main parts; a treater through which the particle-laden gas is passed and a high-voltage power supply to furnish electric power to the treater. This treater consists of an array of emitting and collecting electrodes between which is passed the gas to be cleaned. Electrons, in traveling from one electrode to the other, attach themselves to the particles in the gas, thus causing the particles to travel to the collecting electrode. These accumulated particles can then be gathered into a hopper or other collecting device.

The development of reliable high-voltage power supplies has contributed considerably to the successful operation of electrostatic air cleaning. This equipment is usually required to operate 24 hours a day, 365 days a year. Considerable work has been done to develop control circuits which will permit continuous operation despite the fact that a precipitator is normally an unstable load on the rectifier furnishing the power. The controls also suppress any surges which may occur.

Voltages used are relatively high, being in the range of 30 to 50 kv for large industrial precipitators and 10 to 20 kv for smaller air-cleaning equipment.

The first rectifiers used in this field were mechanical. Electron-tube rectifiers have been coming into their own in the past ten years with the development of high-voltage rectifier tubes with long life. The tube rectifier has numerous advantages. It is quiet, compact, and does not produce ozone, nitric oxides, or generate radio noise.

TRAFFIC CONGESTION AND URBAN TRANSIT

By E. E. KEARNS

Locomotive and Car Equipment Divisions, Apparatus Department
General Electric Company

TRAFFIC jams in urban communities daily take a staggering toll in loss of life, waste of time, and decrease of property values, as well as in direct out-of-pocket expense to every motorist.

Essentially, the traffic problem is one of moving people. Only about 90,000 buses, trolley coaches, street and rapid-transit cars perform the same amount of service as millions of automobiles, because of the vastly greater transportation efficiency of the public-transit vehicle.

For instance, the Lexington Avenue subway in New York has a passenger-carrying capacity equal to twenty, four-lane, grade-separated freeways. On city streets, one lane devoted to trolley coaches is equal in capacity to nine lanes for private automobiles—and the trolley coaches do not have to be parked.

Obviously, the diversion of a substantial part of private automobile travel to rapid-transit vehicles would greatly relieve the congestion. But persons cannot be ruled off congested streets. Business requires many cars and trucks regardless of traffic conditions. But still there are millions whose mode of travel is a matter of choice. If public transportation can provide sufficiently attractive service, it can win over many drivers. To compete with the private car, such service must be *near at hand, frequent, speedy, comfortable, courteous, and priced for economy.*

To render such service, a public carrier must be financially healthy. Otherwise it cannot attract the necessary capital for *modern* vehicles and proper replacement. Multiple taxes hamstring transit systems. Needed fare revisions have been postponed far too long, and increased operating expenses are driving many companies into bankruptcy.

Transit can do much to help itself through good public relations. People no longer ride from necessity. Any effort to win them must begin with good equipment and superior service.

This operating model of a typical smokestack enables visitors to see how a smoke density indicator may be applied to reduce smoke, soot accumulation, and fuel consumption. Receiving its signals from the photoelectric equipment mounted in the stack, an instrument indicates the percentage of smoke density, and a recorder gives a continuous reading of density for operational checks. The exhibit shows also how a magnetic relay, included with the equipment, may be used to ring a warning alarm.

Modern vehicles now available have great rider appeal. When operated and loaded within practical limits, they will give service capable of attracting many who now drive by preference.

Each type of public transit has its place. Rapid-transit trains can best serve the heavy-traffic lines in the largest cities. As a general rule, transit lines on city streets carrying at the peak 300 or more passengers per hour can be served most economically with trolley coaches or PCC streetcars. Light feeder lines, pioneering routes, and certain express services are best handled by buses. In each case, local conditions pertaining to the line involved must be carefully studied to insure the selection of the most economical type and size of vehicle.

The city's problem is *moving people*, not vehicles. Efficient, modern transportation so serves the community in relieving traffic congestion.

The technical
and economic
significance of
developments
and trends in...

NATIONAL SECURITY

IT HAS been stated many times that the past war was won in the engineering offices, laboratories, and shops as much as on the battlefield. Without the products of industry to both arm and protect him, the soldier of today would be impotent in battle.

While the world is still politically unsettled, of which the Korean situation gives graphic evidence, the security of the nation will continue to depend upon its industrial strength. Research and development, coupled with ability to produce, will assure strength to resist any potential aggressor.

AIRCRAFT GAS TURBINES

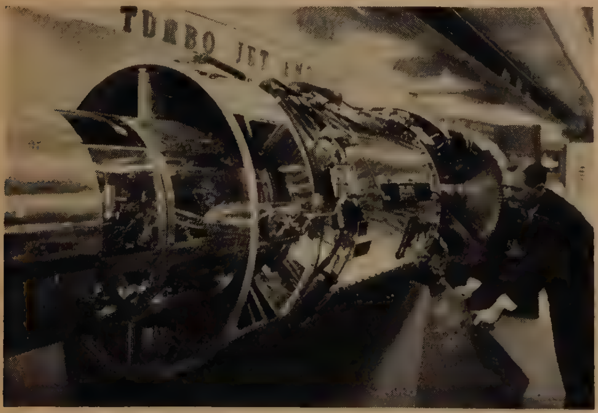
By C. W. LaPIERRE

Aircraft Gas Turbine Divisions, Apparatus Department
General Electric Company

WHEN the aircraft gas turbine proved itself practical for aircraft propulsion, aviation gained a new lease on life. Because faster, higher, and more economical flight is possible with the gas turbine, aviation is on the threshold of a great new era.

Three basic forms of the gas turbine are used in aircraft. The turbosupercharger, enabling piston-engine planes to fly at high altitudes by compressing the rarefied air, was first. The compressor on this device is driven by a turbine spun by the engine exhaust.

Continued development gave several types of World War II airplanes superior high altitude performance and range. Modern piston-engine military aircraft like the Convair B-36 and the Boeing B-50 are supercharged, as well as Boeing's "Stratocruiser," the first commercial application.



H. P. Bish, manager of the Aircraft, Federal and Marine Divisions, operates the throttle of the J-47 jet engine which is cut away to show working parts.

Second in the aircraft gas turbine family was the turbojet, powering airplanes by jet propulsion. October, 1942, marks the first flight of a jet-propelled airplane in this country, the Bell P-59 "Airacomet." Since then, many spectacular records have been established by jet aircraft, including the 3-hr., 46-min. coast-to-coast dash of a Boeing XB-47 bomber, powered by six turbojets.

The third form of aircraft gas turbine is the turboprop—a propeller-driving gas turbine. The first American plane of this type flew in 1943.

Remarkable progress is being made in the development of the aircraft gas turbine, considering the difficulty of the problems facing metallurgists and designers. In spite of very high operating temperatures and rotating speeds, plus the necessity of minimum weight, power output per pound of weight has been tripled. At the same time, operating efficiencies have been increased 40 percent or more and service life has been improved tenfold.

Some of this country's best engineering talent has been devoted to research and design of this new form of aircraft power unit. In addition, many laboratories, including industrial, Air Force, and National Advisory Committee for Aeronautics facilities, are concentrating on aircraft gas turbine research.

MERCHANT MARINE AND NAVY POWER PLANTS

By W. E. JACOBSEN

Federal and Marine Engineering Division, Apparatus Department
General Electric Company

AN ADEQUATE fleet of modern, efficient naval and merchant ships is a vital part of national security. The nation's need for ships to maintain communication lines and deliver men and materials thousands of miles from home was clearly demonstrated by two wars.

Although shipbuilding is now at a low level, much of the existent activity is directed toward individual better design and superior performance. Mass production of standardized designs has given way in both merchant and naval construction.

Naval vessels and merchant ships have no fundamental difference in their propulsion or ship's service systems. The differences that do exist are the result of particular service conditions and of different evaluation factors.

Ships built in this country are generally powered by steam turbines or diesel engines. Depending on the particular nature and duty of the vessel, the transmission between the prime mover and the propellers may take a number of forms. The trend toward higher speeds of both turbines and diesels has made a speed reducing means desirable in most cases. Reduction gears are in common use. Electric drive, though seldom chosen because of this factor only, also permits speed reduction.

Improvements in the art and practice of gear cutting as developed after World War I made possible a significant advance in the use of steam turbines for propulsion. As the gears improved in quality, higher speed turbines could be used, resulting in lower weight, greater fuel economy, and improved reliability.

The B-29 bombers which have been operating over Korea have turrets similar to this one aboard the MPA Special.

By increasing the temperature and pressure of the steam through advancements in boiler and turbine design, fuel oil requirements have been reduced from one lb to 0.52 lb per hp-hr in the past 25 years. Equipment now being built will operate at even higher steam conditions and cut the fuel rate to less than 0.5 lb per hp-hr.

Electric-drive propulsion systems generally require special service conditions for economic justification. Vessels that maneuver extensively in restricted waters, such as ferryboats and tugs, or vessels that have dual use for large amounts of electric power, such as fireboats and dredges, are most suitably served by electric drive with its inherent flexibility, ease of maneuvering, and low standby losses.

In the past forty years, ship's service electric power requirements have increased from a few kilowatts to 4000 kw or more on passenger vessels and 500 kw on cargo vessels. Some large passenger vessels have approximately 10,000 kw of ship's service generator capacity.

SHIPBOARD GAS TURBINES

New developments point to the possible use of the gas turbine in ship propulsion systems. A particularly attractive arrangement involves the combined use of a gas turbine and a steam turbine plant. In a version of this arrangement for a naval vessel, the steam plant would be used for ordinary cruising, and would be supplemented by gas turbines for the relatively high peak power required for only short periods of time. A proposed merchant ship arrangement that appears to offer a favorable fuel rate would use the gas turbine exhaust heat to generate steam for the steam turbine.

More recent and more revolutionary is the disclosure that the Navy is proceeding with the building of a nuclear powered ship. This project may well indicate the shape of things to come when ships will no longer be limited by fuel carrying capacity. At that time fuel economy, as such, will not be the restricting consideration that it is today.

GUN-FIRE CONTROL EQUIPMENT

By **R. E. COUTANT** *and* **J. D. THOMPSON**

Aeronautics and Ordnance Systems Divisions
Apparatus Department
General Electric Company

AT THE end of World War I, air attack was directed mostly against ground installations, and the airplane was only a potential threat to warships and other floating targets. As a result, anti-aircraft defenses consisted almost entirely of land-based guns and pursuit aircraft.

Crude computing devices had been developed to determine the necessary amount of "lead" for the larger guns, but machine guns were aimed entirely by tracers. Anti-aircraft guns of all sizes were trained and elevated by muscle power.

Pursuit aircraft were armed with small-caliber fixed machine guns which were aimed by pointing the airplane at the target. In the typical "dog-fight" of that war the victory was won by the most skillful pilot in the most maneuverable airplane.

At the close of the past war, the picture had changed completely, and it is still changing with the development of faster, more deadly aircraft, rockets, and guided missiles. Fast, accurate power drives are a necessity for most air-borne guns, and for all but the lightest land-based and ship-based guns. No human gunner, without the aid of a power drive, can train a machine gun against the tremendous wind resistance encountered in a modern high-speed airplane. Lead computations must be instantaneous, accurate, and based on automatic power-driven target tracking rather than manual tracking.

SYSTEM TRENDS

In the case of land-based and ship-based systems, tracking must begin long before the target is in visual range. The most noticeable tendency, therefore, is the increasing reliance on long-range radar for target detection and on fire-control radar for automatic tracking.

Radar is no longer added to a fire-control system as an afterthought; instead, the system is built around radar. With modern naval fire-control equipment, the entire system can be controlled through all phases of an engagement by radar operators stationed below decks.

Parallel developments have taken place in air-borne fire-control systems. The modern bomber carries fire-control equipment no less complex than that of a battleship. With increasing flight altitudes, the gunners are disappearing from the gun turrets. They are stationed instead in pressurized areas, and are provided with search and tracking radar, optical sights, and automatic lead-computing equipment through which they control the aiming and firing of the guns.

Armament on interceptor planes is likewise increasing tremendously in complexity as higher speeds and longer ranges make the attack problem too difficult for the human pilot. Today, the tendency is toward automatic radar control of the plane itself through its automatic pilot, thus making the plane a guided missile until after the attack has been completed.

Development of fire-control equipment is keeping pace with the development of the airplane and is increasingly concerned with defense against rockets and guided missiles. At present the most advanced studies are directed toward the solution of the problem presented by missiles and airplanes travelling at supersonic speeds. Much progress has been made and more can be expected with the continuing improvement in radar techniques, automatic tracking and computing equipment, and power drives.

GUIDED MISSILES

By DR. C. F. GREEN

Aeronautics and Ordnance Systems Divisions
Apparatus Department
General Electric Company

WORLD WAR II forcefully brought to the attention of all the world the great potential striking force of rockets and guided missiles. However, the rocket at the end of the war was in the same stage of development as was the airplane at the end of the first world war.

Advances in all technical fields are required to make possible the needed performance for future usable weapons. Among these are developments of new and greater energy fuels and propellants, more powerful motors, new heat-resistant materials, more accurate guidance and navigational equipment, better control means, and improved radar. Needed above all is greater knowledge of ballistics, aerodynamics—particularly supersonic phenomena—and of the upper atmospheric.

To be effective, a missile must be able to reach out long distances, locate a target, and then demolish it. The system performance necessary to meet these basic requirements is comparable to the modern fully manned bomber, interceptor plane, or submarine. However, add to this the problem of a missile system with ability to handle stationary and movable targets, that can handle more than one missile at a time, with freedom from enemy jamming, and above all an accuracy at the distant point of impact equivalent to that of artillery fire; then one can justify the great effort that is being put into this field.

In the interest of national security, not much of this vital work or its extent can be disclosed for security reasons. Such significant records as those of altitude rockets at White Sands and the 242-mile-high two-stage Bumper rocket are evidence of achievements.

Engineers are prepared to go even further than long-range earth-bound missiles. Already envisioned are satellite and inter-planetary vehicles. But first, defensive and offensive weapons must be provided. The United States must be made self-sufficient in scientific advances and unmatched in production "know how" where any type of guided missile is concerned.

EXPERIMENTAL METEOROLOGY

By DR. V. J. SCHAEFER

General Electric Research Laboratory

SINCE the beginning of time, man has taken the weather just as it came. As a result of experiments in meteorology, however, it appears that man may eventually have at least partial control.

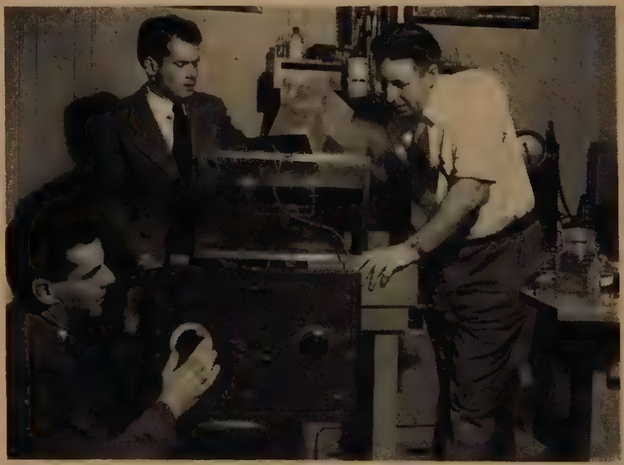
Sponsored by the Army Signal Corps and the Office of Naval Research, study has been made of the processes which occur in the atmosphere and lead to the formation of snow and rain, as well as those which either moderate or prevent such developments.

Through use of dry ice and silver iodide introduced into supercooled clouds by aircraft, it has been found possible to form tremendous quantities of ice crystals in the clouds before they occur under natural conditions. Introduced from airplanes, these two materials have "triggered off" unstable cloud systems and caused striking effects in the atmosphere on many occasions.

Large holes have been produced in a solid, cloudy overcast. Extensive snow crystal areas have been formed in regions which were previously free of clouds. Clouds have been made more persistent by "overseeding" them. Rain storms have been induced in specific regions by seeding cumulus clouds.

On the basis of scientific knowledge established as the result of activities, it is believed that severe storms, such as those which produce hail, lightning, and torrential rains and high winds, may someday be prevented. The method will be to dissipate the clouds before they reach the size required for the development of these damaging characteristics.

The general program of Project Cirrus, the official name of this study, has led to widespread activity throughout the world by public and private agencies. In the future, the economic and scientific significance of this unusual activity will be determined.



Engineers help Dr. V. J. Schaefer in an experiment with the ultrasonic generator for the Project Cirrus exhibit.

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Telemetering principles are now thus extensively applied in such diversified industries as steel mills, gasworks, synthetic rubber plants, oil refineries, and installations involving the reclamation of expensive solvents. All engineers and mechanical development supervisors throughout the chemical and process industries will wish to be informed about the practical aspects and the possibilities of this valuable application of instrumentation.

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The purpose of this volume is to help the materials engineer select the type of metal or alloy which is best able to meet a given set of service conditions. No other book gives this particular type of information, which will be welcomed by writers of materials specifications, industrial designers, metallurgical engineers and mechanical engineers.

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HIGH LIGHTS AND SIDE LIGHTS

200 Tons of Talc Per Day

Talc particles 55 times smaller than can be seen by the human eye are being produced by a manufacturer in upstate New York. This plant, completely powered by electric equipment, is turning out 200 tons of talc a day to meet the needs of paint, ceramic, and cosmetic manufacturers as well as other industries which use talc as a filler.

The talc is reduced to micron and submicron sizes in a revolutionary type of air-powered pulverizing mill. The most unusual feature of the mill is the lack of moving mechanical parts in its "fluid energy" reduction process. Crushed rock enters the mill through a venturi-injection system and is picked up by blasts of hot compressed air and set in motion. Talc particles in the mill circulate at a very high velocity. Under furious agitation by the jets of air, the fast-moving particles bombard each other, causing almost complete disintegration.

A 1750-hp 4160-volt synchronous motor, selected for its efficiency and ability to improve plant power factor and to maintain constant speed under wide load variations, drives the air compressor

Although there are only a few pounds of talc in the mill at any time, the speed is so high that as much as six tons will pass a given point in one minute. Each time a particle circulates about the chamber it becomes smaller, and it may require as many as 1500 to 2500 round trips before it reaches the proper size.

An outdoor substation with a rating of 3750 kva, 85 kv, steps down the high-voltage incoming power to 4160 volts for plant distribution. Three 500-kva load-center unit substations further reduce the voltage to 480 for utilization in load areas.

9000 Feet of Underground Lighting

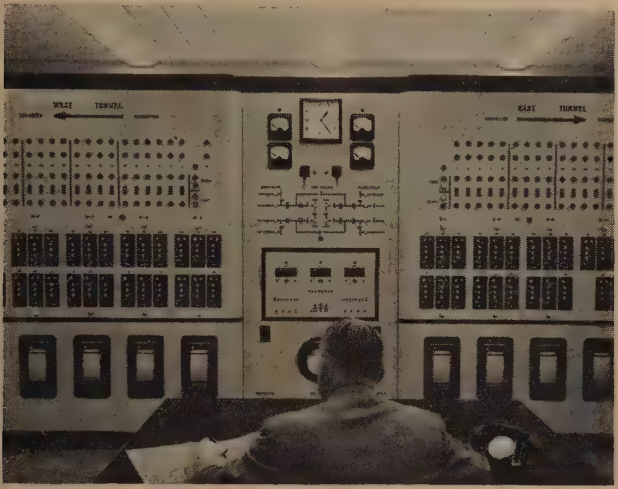
The longest continuous lighting installation in the world, in which four ribbons of fluorescent light extend almost two miles, is in the Brooklyn-Battery Tunnel, which passes beneath the East River between lower Manhattan and Brooklyn.

An outstanding feature of the electrical system, the lighting installation includes a total of 5776 individual lamps housed in clear Pyrex "pipes" near the top of the side walls of the twin tubes. Sixteen control cubicles and saturable reactors regulate the current through the lamps and, in turn, their light output.

Astronomical clocks turn on a higher intensity in the portal sections of the tunnel during daylight hours. Thus, driving at normal traffic speed (40 mph in the tunnel), drivers can make a gradual visual adjustment between daylight and tunnel light.

Twenty-four lighting circuits, three running in each direction on both sides of both tubes of the tunnel, supply electricity to the lamps. The system is so laid out that loss of any part of the power supply—including complete loss at one end of the tunnel—will not leave any section of the underwater passage in darkness. There are almost 3000 fluorescent lighting transformers in the series circuits, and light meters along the walkways continuously register the illumination level in the tunnel.

Power for the new tunnel is supplied through six switchgear units—two each in Manhattan, Brooklyn, and the Governors Island Ventilating Building. Besides the necessary ventilating and lighting power, electricity is furnished for traffic signals, alarms, pumps, and building facilities such as elevators, lights, vacuum cleaners, and machine shop. Photoelectric over-height indicators at the tunnel approaches sound an alarm and turn the traffic signals red when a light beam is interrupted by a vehicle that is too tall to pass safely through the tube.



Operator at main control switchboard for the tunnel

More than 1700 miles of wire link the components of the tunnel's electrical system with each other and with the main control board in the Service Building in Brooklyn. This board is the central "brain" of the system and permits control of ventilation to keep the carbon-monoxide concentration in the tunnel below a predetermined level. Carbon-monoxide detectors register the gas concentration throughout the tubes; the measurements are continuously relayed to the control board and the flow of vehicles or speed of ventilation regulated accordingly.

Video Medico

Four and a half tons of TV equipment, including a portable television station and receivers, together with a crew of electronics engineers, are making a 20,000-mile tour of Latin America by air. There the equipment, capable of transmitting and receiving up to 25 miles, will be used to televise surgical operations and educational programs.

The project, called "Video Medico," made its first official stop at San Juan, Puerto Rico. The remainder of the schedule includes demonstrations in Brazil—at the Brazilian Congress of Gastro-Enterology at São Paulo; in Argentina—at the Congress of the International College of Surgeons at Buenos Aires; in Venezuela, and Mexico. In each country, Latin American surgeons and physicians will see, many of them for the first time, televised demonstrations of surgical and clinical proce-

(Concluded on next right-hand page)

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THE RONALD PRESS COMPANY
Fifteen East Twenty-Sixth Street New York 10

If you BUY or SELL component parts or materials, you are interested in

PRODUCT DESIGN & DEVELOPMENT NEWS

PRODUCT DESIGN & DEVELOPMENT

FOR THE ORIGINAL EQUIPMENT MARKET

IF YOU BUY . . .

PD&D can save you time and money.

PD&D is sent without charge to men in the U.S.A. who are designing and developing durable goods and who are specifying component parts and materials. Each man receives an individual copy—without being bothered by subscription solicitations—without waiting for company "pass-on" copy to come along.

PD&D brings its readers each month news of new parts, materials and processes, plus progress reports on older ones. And only such news. It is a "where to buy" newspaper, not a "how to do" paper. To save its readers time, the news is presented in tabloid form, both the editorial and advertising columns are boiled down to basic essentials. In a recent survey our readers voted to maintain these advertising restrictions because, as one design engineer put it: "Advertising departments tend to expand area without adding pertinent data. The more subjects there are on one page, the easier it is to scan for information of particular interest."

For the convenience of those desiring additional information, every product description and advertisement is numbered and a free reader service card with corresponding numbers on it is enclosed. All the reader has to do is to ring the numbers for which additional information is desired, fill in his name and business connection, and forward the card to PD&D. As a further time saver to readers who are in a real hurry, we include in our editorial descriptions, wherever possible, the name of an individual who is in a position to answer direct inquiries either by mail or telephone. This is the reason for including both the company address and telephone number.

If you believe the service PD&D is rendering would be helpful to you and that you are a person whom our advertisers (who pay the bill) would be interested in reaching, we would be delighted to hear from you. (Our circulation at present is confined to the U.S.A.)

IF YOU SELL . . .

PD&D is designed to give you a lot of coverage at low cost—and for those who want it, tangible evidence that their advertising is being read.

PD&D is now going to over 33,000 men by name and title who are responsible for design and development in all the durable goods manufacturing companies in the U.S.A.

Most of these engineers have requested that they be put on the list to receive PD&D each month, but the best evidence that they are actually reading it is the number of inquiries received by manufacturers whose products are described or advertised. These inquiries are received by telephone, letter and reader service card. (See column to the left on this service to our readers.)

Over 30 surveys, made of the men who have sent in these inquiries on individual advertisements, have shown conclusively the seriousness of their desire for additional information. The percentage of actual sales resulting from these inquiries has of course varied with the products the companies advertised. But the original equipment market is a "jackpot" market in addition to being a slow moving one, so if only one sale is made the advertising has paid for itself many times over—and it takes just as long for your competitor to move in.

Advertising in PD&D is restricted to 1/9 and 2/9 page units. Space units are the standard 3¼" x 4¾", and 3¼" x 9¾". Recent surveys among our readers have shown us that, by an overwhelming majority, they want us to maintain these restrictions. In many cases these restrictions call for special, boiled down copy, but that seems to be just what our readers want. They claim they quickly read every item in PD&D in their search for helpful information. Moreover, under this arrangement, all advertisers get an even break and are not competing with one another for dominating space.

The cost of advertising in PD&D is a flat rate of $120.00 per 1/9 page unit. There is no discount for a number of insertions or for using more than 1/9 page per issue. Our main reason for having this arrangement is that with such a low rate, short-rate bills would just be a pain in the neck for everybody involved. But it does have the advantage of enabling advertisers to try out PD&D without contracting for a large investment.

The consistent advertising growth of PD&D in the 3½ years since it was founded is the best assurance that it is worthy of the test. Because we have produced tangible evidence of readership of all advertisements since we started (even though some advertisements had previously appeared elsewhere), every issue has shown a gain over the corresponding issue of the previous year, and the present advertising volume is 7 times that of our first issue.

If you want to see a lot of data on how advertising can really perform, give our representative some time the next time he calls.

PUBLISHED BY FRANKLIN H. JOHNSON, Inc.,
138 EAST 47th STREET—NEW YORK 17, N. Y.
ELDORADO 5-7011 • PLAZA 9-2576

ADVERTISING REPRESENTATIVES: Al J. Kaiser, Vice President—138 E. 47th St., New York 17, N. Y. ELdorado 5-7011; 12 Hillsdale Rd., Wapping, Conn. Manchester 2-1694 ● Franklin H. Johnson, Jr.—138 E. 47th St., New York 17, N. Y. Eldorado 5-7011 ● William A. Edwards—333 No. Michigan Ave., Chicago 1, Ill. ANdover 3-5976; 1014 Sheriden Rd., Evanston, Ill. GReenleaf 5-7174 ● James J. Shalvoy—850 Euclid Ave., Cleveland 14, Ohio Superior 1-6700; 640 Griswold St., Detroit 26, Mich. WOodward 1-0814

dures. The televising of surgical operations permits a close-up view of the incision area.

The Latin American tour followed a New York preview at which more than 200 officials of the U. N., representatives of Latin American countries, and physicians watched an abdominal operation being performed at Bellevue Hospital.

Twelve 16-inch rectangular-tube television sets were set up in the United Nations building, while eight receivers in Bellevue's auditorium afforded a view of the operation to medical students and doctors there.

Electric Eye on Wheels

Improvements in street lighting, with a decrease in the number of night traffic accidents and fatalities, are foreseen as the result of the development of a new light-measuring and recording device, the Rapid Recorder for Measuring Street Illumination.

The new device consists of an electric eye on wheels, connected by a 30-ft aluminum tube to an automobile carrying an amplifier and graphic recorder. The light-sensitive "eye," riding only six inches above pavement level, trails far enough behind the auto to have an unobstructed view of the highway lighting, to permit the accurate measurement and recording of varying amounts of light along endless miles of roadway at the rate of ten to twenty miles per hour. This is at least from 25 to 100 times faster than could be done by previous methods involving the laborious task of making separate measurements on 10-ft centers.

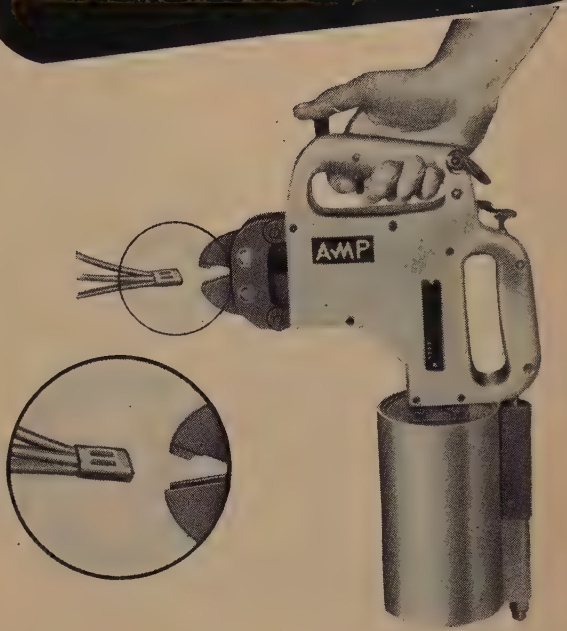
Amplifier and graphic recorder are carried inside the automobile that tows the electric eye at the end of a 30-ft tube

It is estimated that measurements now taken in a single night with the new rapid recorder would, by former techniques, require four months to gather. Furthermore, the results by the new method are more nearly complete and accurate.

The new device was unveiled for the first time at the Great Lakes Regional Conference of the Illuminating Engineering Society in Buffalo (N. Y.), where it was hailed by nationally known traffic and lighting engineers as a major contribution toward improving highway conditions at night.

With the driving mechanism of the recorder connected to the auto's speedometer cable, the distance traveled is accurately recorded on a six-inch paper roll of tape. This record is so simple and obvious as contrasted to the complex results of the past that many additional advantages are seen. The municipal official, for example, will more quickly grasp the meaning of the study and see the need for better street lighting; safety officials will have a new yard stick for correlating night-accident experience with the existing illumination; lighting designers will be able to determine whether lighting layouts are adequate; and lighting-equipment makers will be aided in checking their laboratory photometry against actual field results.

"stub" position crimps are possible with AMP'S NEW PNEUMATIC TOOL



INTERCHANGEABLE HEADS

FOR CRIMPING SOLDERLESS TERMINALS ON WIRE SIZES FROM #6 to #1/0.

This sturdy AMP tool features interchangeable crimping heads for either conventional "side position" or novel "end" position crimping, as well as a double set of handles and triggers. A suspension loop enables tool to be supported from above. Air cylinder is constructed of seamless tool steel—safety factor 300%. Toggle action jaws insure complete crimping cycle. Operates from standard shop outlets of 85 p.s.i.

AMP

AIRCRAFT-MARINE PRODUCTS INC.
1312 N. 4th Street, Harrisburg, Pa.
Canadian Representative:
R. M. Hutcheson, 10 Nordale Crescent,
Hardington, P. O., Toronto 15, Ont., Canada • ELgin 5647

AMP Trade Mark Reg. U. S. Pat. Off. U. S. Patents Pending

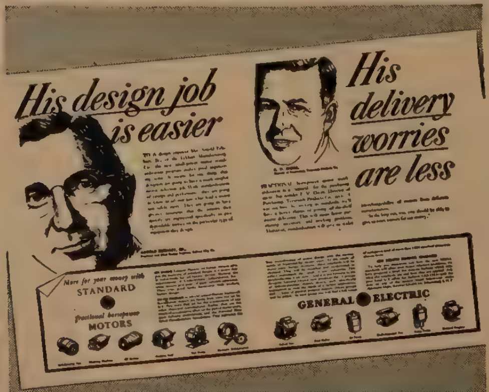
An Advertising Agency'

GETTING THE "WHY-BUY" — Basford researchers were asked to measure the influence of the G-E monogram on the purchasing habits of fluorescent fixture buyers. A penetrating survey was planned and conducted by Basford personnel in the test city of Stamford, Conn. The results were extremely helpful in subsequent planning.

PACKING 'EM IN — One of the newest and best More Power To America programs is "Textiles Unlimited," an insight (on film) into the industry's future. Basford was asked to build up the potential audience. An unusual "gimmick" direct mail campaign (winner of a Direct Mail Adv. Assoc. prize) coupled with space advertising, enabled G.E. to hang out the S.R.O. sign for months in advance. (Above) J. Stanford Smith, advertising manager of General Electric's Apparatus Department, reviews the direct mail campaign with R. E. Insley, account supervisor for General Electric.

"DIVINE INSANITY" — That's the title of a 2-part skit recently conceived, cast and produced by Basford. The occasion was a conference of electric utility executives held by General Electric. For 5 days before the premiere, a Basford "producer" was on the spot, polishing the production until it reached professional standards.

WHAT DO FARMERS READ? — (Right) The best way to find out is to go out and talk to them, get the "feel" of their wants and attitudes. The value of this grass roots approach was recently demonstrated when a G-E advertisement was rated 6th in a field of 110 ads appearing in a national farm magazine. The standard — greatest amount of *thorough readership* for advertising dollars spent!



His design job is easier

His delivery worries are less

More for your money with STANDARD fractional horsepower MOTORS

GENERAL ELECTRIC

IDEA ON THE MARCH. — (Left) "Specials" were making things tough for G.E.'s small motor division. Could appliance and machinery manufacturers be sold on using "standardized specials"? A highly credible testimonial advertising campaign seemed to be the way to sell the idea. One year later, General Electric was able to report (1) considerably fewer models on the production line and (2) a decrease in the price of its small motors.

that wears many hats!

AD CRAFTSMEN, skit producers, pulse feelers, tag campaign planners—these are but a few of the roles G. M. Basford Company has assumed in its capacity as advertising agent for General Electric Company's Apparatus Department.

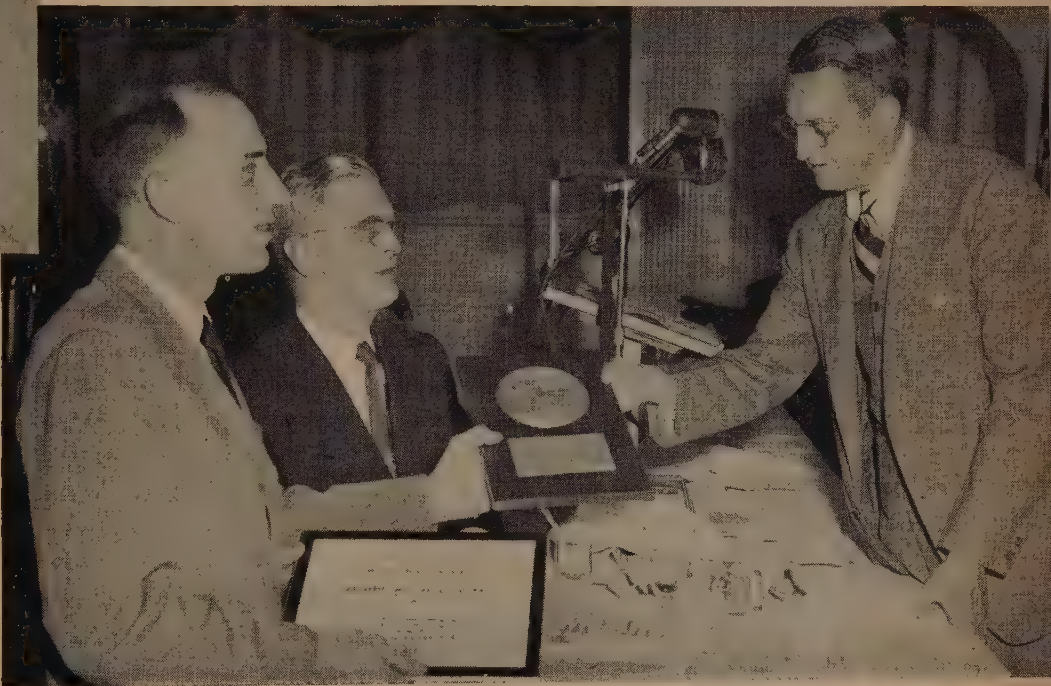
How does the client like this ability to "wear many hats"?

Listen to J. Stanford Smith, advertising manager of the Apparatus Department of General Electric: "With the exception of skywriting (and we may use that someday), there's hardly a medium of communication we don't use to help market our goods. And even though our relationship is more than 10 years old, I still am surprised, and pleased, at the adaptability of the Basford organization. We've assigned them some pretty tough jobs but they've always come up with original thinking, good workmanship, and on-time deliveries."

A glimpse at these typical G-E marketing assignments will give you an idea of the breadth, and depth of Basford service. At your convenience, we'll be glad to discuss it further with you.

ITTLE TAG, BIG VOICE—(Above) .E. wanted a vehicle which would ramatize all the intangibles that go nto the making of a fluorescent light allast the customer never sees. Basford ame up with a tag to be attached to ne complete fixture—and helped develop a complex merchandising and dvertising campaign to users, fixture nanufacturers, electrical contractors, nd specifiers. The payoff was in the rge number of new manufacturing ustomers corralled. G.E. thanks the g for a lot of this new business.

"OSCAR WINNER"—(Below) E. F. Hamm, then president of the Associated Business Papers, hands R. B. Reid, G-E industrial advertising division manager, and Fred E. Adams, Basford vice-president, award for General Electric Tri-Clad motor campaign, voted "best" among business paper campaigns.



HELPING THEM SELL—(Right) By their nature, many electrical products sold through hardware outlets do not move in large volume. One way out is the "related item" sale. This "Electrical Chore Helper" promotion kit prepared by Basford for G.E. dealers in rural areas got many a slow item up front on the counter—where it could be seen, and sold.

new "twin-motor" temper mill drive
holds high tension accurately at 3700 fpm!
another example of drive engineering at work!

NUTS AND BOLTS STUFF—Do they read "long" copy? They do if they're technical men and it's helpful information they're getting. This G-E series is aimed at electrical engineers in steel mills. It's in its fourth consecutive year.

G. M. BASFORD COMPANY

Marketing & Advertising

Congratulations General Electric

. . . for going out to America's Mainlines with the More Power to America Special—for presenting *visually* to American industry 2000 electric ideas in action to help produce *more goods for more people at less cost.*

Congratulations, too, for going constantly *beyond* the mainlines to every corner of the United States with ideas and information presented with the *double impact* of modern audio-visual techniques.

Henning and Cheadle is proud to have had a part in helping General Electric reach more people with more information in less time. Films, literature and other visual media, for the More Power to America Program and for sales training and promotion programs, have aided General Electric in serving more people and moving more goods.

HENNING
▪ and ▪
CHEADLE
Inc.

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and training programs . . . materials

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- Alligation
- Arithmetical and Geometrical Progressions
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- Preferred Numbers
- Equations
- The Slide-rule
- Logarithms
- Hyperbolic Logarithms
- Calculation of Plane Figures
- Calculation of Solids
- Pappus or Guldinus Rules
- Contents of Cylindrical Tank at any Level
- Circles and Equivalent Squares
- Solution of Triangles
- Natural Trigonometric Functions
- Logarithms of Trigonometrical Functions
- Geometrical Propositions and Problems
- Standard Mathematical Signs, or Symbols
- Standard Engineering Abbreviations
- Standards for Drawings
- Methods of Indicating Surface Finish
- Composition and Resolution of Forces
- Mechanical Powers
- Center of Gravity
- Moments of Inertia
- Motion, Force and Work
- Radius of Gyration
- Centrifugal Force
- Flywheels
- Radians
- Factors of Safety
- Strength of Metals and Other Common Materials
- Moments of Inertia Tables
- Punch and Shear Frames
- Section Moduli and Moments of Inertia
- Properties of Shafts, Standard Pipe, and Structural Shapes
- Beam Formulas
- Structural Timbers
- Strength of Columns
- Strength of Flat Plates
- Strength of Cylinders
- Riveting and Riveted Joints
- Wire and Sheet-Metal Gages
- Wire Rope
- Spring Design
- Strength of Shafting
- Friction
- Design of Plain Bearings
- Standard Ball and Roller Bearings
- Lubricants
- Keys and Keyways
- Clutches and Couplings
- Friction Brakes
- Cams and Cam Design
- Cam Milling
- Spur Gearing
- Bevel, Spiral Bevel and Hypoid Gearing
- Worm-gearing
- Helical Gearing
- Herringbone Gears
- Epicyclic or Planetary Gearing
- Gear Measurement
- Ratchet Gearing
- Belts and Pulleys
- V-Belt Drives
- Pulley and Gearing Speeds
- Chain Transmissions
- Crane Chain and Hooks
- Standard Bolts and Nuts
- Standard Machine and Cap-screws
- Standard Set-screws
- Wood Screws, Nails, Spikes
- Screw Thread Systems
- Measuring Screw Threads
- Allowances and Tolerances for Plain Fits
- Standard Allowances and Tolerances for Screw Threads
- Measuring Tapers and Angles
- Rules and Constants for Setting Sine-bars
- American Standard Gages
- Tapping and Thread Cutting
- Change Gear Ratios
- Thread Milling
- Thread Grinding
- Thread Rolling
- Change Gears for Helical Milling
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- Cutter Grinding
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- Punches and Dies
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- Files
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- Standard Tapers
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- Jigs and Fixtures
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- Iron and Steel Manufacture
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- Forging—Welding
- Soldering, Brazing
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- Coloring Metals
- Weights of Materials
- Heat
- Properties of Air
- Hydraulics
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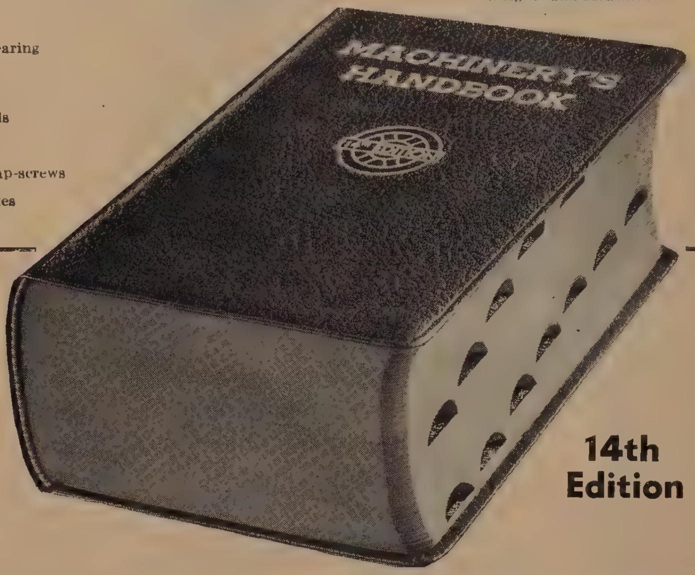
- Lutes and Cements
- Standards for Electric Motors
- Motor Characteristics
- Electric Motor Applications
- Electric Motor Maintenance
- Manufacturing Plant Appraisal
- Weights and Measures

Accurate, Up-to-date Information for Designers and Builders of Everything Mechanical



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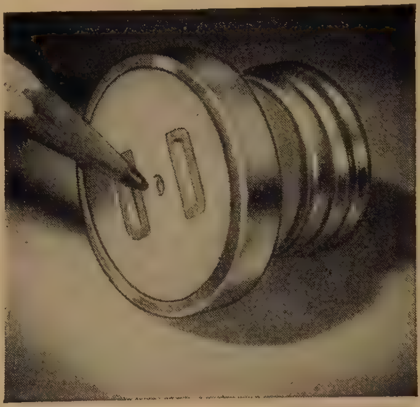
AND WHAT THEIR MAKERS HAVE TO SAY ABOUT THEM

Plug Body

A new electrical plug body, Model 1200, of sturdy construction with a built-in neon glow lamp, designed primarily for industrial uses where constant usage causes wear and breakage, and frequent replacements are necessary. This plug body will outwear the usual electrical receptacle, but as replacements become necessary they can be made in a matter of seconds. The glow lamp serves as a pilot to indicate the presence of power, or as an orientation light when used in a lamp socket.—*Industrial Devices, Inc., Edgewater, New Jersey.*

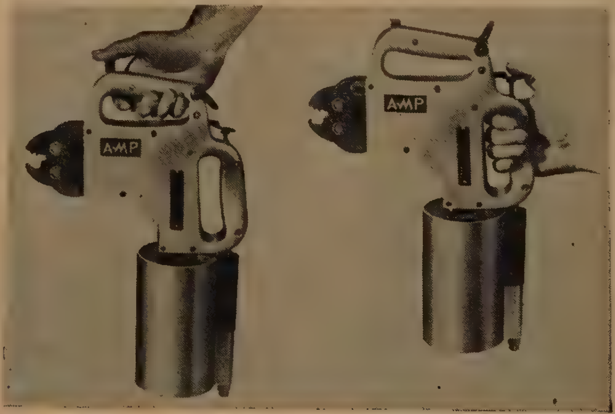


Arc-welding Electrode

A new improved arc-welding electrode, the W-52, a reverse-polarity d-c rod designed for high-quality welding of low-alloy high-tensile steels. It can be widely applied in the welding of high-pressure piping and of castings where high tensile strength and resistance to creep at high pressures and temperatures are desired. Good bonding action at the fusion zone on horizontal fillets and less tendency to produce pinholing on vertical down welds are some of its characteristics. This electrode of carbon-molybdenum is available in $\frac{5}{32}$ in. and $\frac{3}{16}$ in. diameters for field trial.—*General Electric Co., Welding Divisions, Schenectady 5, N. Y.*

Pneumatic Hand Tool

A new air-operated tool for crimping solderless terminals to wire combines the advantages of power press with the ease and flexibility of a hand tool. A special feature is the detachable heads for either the conventional side-position or end-position crimping. A suspension loop is attached to the top of the tool to enable it to be supported from above, and a double set of handles and triggers provide versatility of operation. When tool is supported, the operator uses the side handle; when tool is being carried or lifted manually, the top handle and trigger are



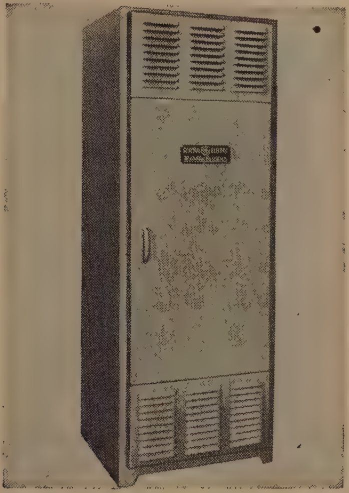
usually more convenient. Air cylinder is of seamless tool steel with a safety factor of 300 percent. The carefully hardened toggle-action crimping jaws insure uniform pressures, and a complete crimping cycle from standard shop outlets of 85 psi.—*Aircraft-Marine Products Inc., 1540 N. 4th St., Harrisburg, Pa.*

Wiring Device Mounting Strap

A new mounting strap, called the Camstrap, designed to speed and simplify installation of Despard interchangeable wiring devices. Only three operations are required to lock wiring devices in this strap: the cam is opened; the device inserted; and the cam closed, locking the device securely in place. Removal is just as easy, speeding interchanging, with no strap distortion. The entire operation can be done with the fingers, eliminating the need for a special screwdriver.—*Pass and Seymour, Inc., Syracuse 9, New York.*

Oil-immersed Selenium Rectifier

A new oil-immersed selenium rectifier especially designed for electroplating, particularly "barrel" plating. The unit consists of a transformer, fan, and 12 rectifier stacks arranged in a steel casing. Each stack, hermetically sealed in an oil-filled can, contains matched selenium cells connected in parallel through heavy internal bus bars to mechanically sealed terminals, utilizing Neoprene for sealing and glazed porcelain for insulation. The unit is available in either 6/12 volts, 1500/750 amp, 230/460 volts a-c, 60 cycles, three phase, or 9/18 volts, 1500/750 amp, 230/460 volts a-c, 60 cycles, three phase.—*General Electric Co., Rectifier Divisions, Schenectady 5, N. Y.*



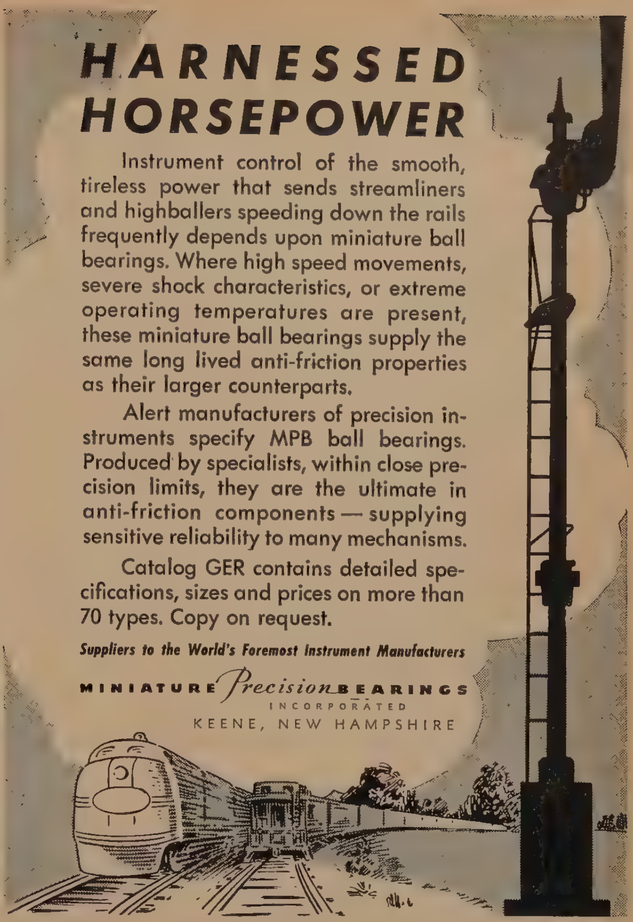
Infrared Spectrometer

Mobility, all-metal cabinet, faster recorder, and new wavelength drive are among the improvements broadening the applications of Model 12-C infrared spectrometer. The completely equipped unit passes easily through ordinary industrial doors and operates immediately where water and electrical service connections are available. Controls are readily accessible to operator in either a sitting or standing position—*The Perkin-Elmer Corp., Glenbrook, Conn.*

Lamination

A new oriented-silicon steel lamination permits reduced transformer stacks with resultant savings in materials and weight. Outstanding characteristic of the new lamination is higher permeability, with lower core loss. As a result, this material offers transformer designers the choice of greater efficiency or fewer laminations. Performance curves indicate that stacks can be reduced as much as 50 percent in some instances, with resultant savings in copper and weight.—*Thomas and Skinner Steel Products Co., Indianapolis 7, Ind.*

(Concluded on next page)



HARNESSED HORSEPOWER

Instrument control of the smooth, tireless power that sends streamliners and highballers speeding down the rails frequently depends upon miniature ball bearings. Where high speed movements, severe shock characteristics, or extreme operating temperatures are present, these miniature ball bearings supply the same long lived anti-friction properties as their larger counterparts.

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CINCINNATI 27, O.

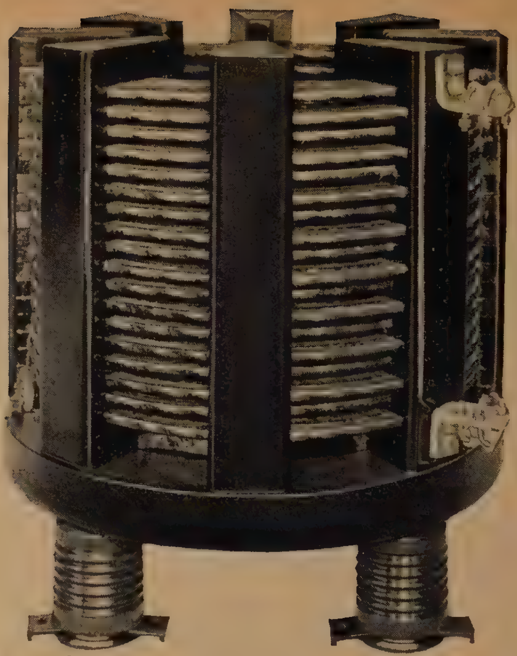
ASBESTOS
FOR THE ELECTRICAL
INDUSTRY

Wherever you look in the electrical industry, you'll find asbestos products. A typical instance is shown in the photo: K&M Asbestos Woven Tape used as an outer wrapping for conductor coils.

Inorganic, strong, and flexible, K&M Asbestos Tape readily conforms to irregular contours—provides required protection against heat without deteriorating.

K&M Asbestos Textiles are available in the forms of roving, yarn, thread, cord, tubing, and cloth. These textiles all meet—and in many cases, surpass—A.S.T.M. Standards. Each type is made with the same careful workmanship, under the same strict laboratory control, that have helped K&M maintain its leadership in the field of asbestos textiles for more than 50 years!

Whatever your textile insulation problem, it will pay you to investigate K&M Asbestos Textiles. Write, specifying your needs.



General Electric Outdoor Current-Limiting Reactor

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Two new presses of one- and two-ton capacity known as the F-10 and F-20 respectively, have been added to the line of air-operated Han-D-Presses. These hydraulic presses are self-contained and they can be used where compressed air is not available. They provide a fast-acting precision unit for speeding up light production operations such as staking, marking, broaching, punching, riveting, and press-assembly. A 1½-hp 1800-rpm motor operates a 3.3-gpm constant-volume pump. An easily accessible, adjustable relief valve makes it possible to adjust the ram pressure. Stroke of the press is 6 in.; gap 10 in.; reach 6 in.; and over-all height above the bench is 28 in.—*Hannifin Corp., 1101 So. Kilbourn Ave., Chicago 24, Illinois.*

Post Lamp

A new all-purpose all-aluminum post lamp designed for the lighting of sidewalks, lawns, driveways, outdoor fireplaces, boat docks, lake cottages, and the like. The lamp is constructed of cast aluminum top and bottom, four heavy aluminum corner pieces to tie the top and bottom together, and a cast ornament at the top which also serves as a vent for the hot air within the unit. A porcelain socket, a polished brass gallery which holds a No. 2 frosted chimney, and four pieces of double-strength crystal glass are the components of this attractive and weather-resistant post lamp. Brass screws are used throughout.—*Fender Specialty Co., 3025 Emerald Dr., Kalamazoo, Michigan.*

Low-frequency Coil

A new Hi-Q coil for sub-audio frequencies can be made available to customers' specifications. These coils have high-Q and stable characteristics for frequencies from 0.1 to 10 cycles. A typical unit provides an inductance of 300,000 henrys with Q of 10 at 0.15 cycles, and Q of 30 at 0.5 cycles. The coil is designed for a 1-volt a-c 0.1-ma d-c circuit.—*United Transformer Co., 150 Varick St., New York 13, N. Y.*

Silicone Resins

Two new silicone resins have been developed for electrical applications. One, No. 81132, is a flexible resin of good drying speed intended for use as a coating on glass cloth and sleeving, and as a sticker for mica-glass tape and other flexible mica products. Tough and fast-drying without a catalyst, it has excellent build on glass cloth and good heat life. It is supplied as a 60-percent solution in toluol. The other resin, No. 81145, is supplied as a 50-percent solution in petroleum spirits. Designed for bonding and impregnating motors, generators, and transformers requiring Class H insulation, it can however be used in bonded mica, mica tape, and glass combinations. When properly cured it is a relatively hard resin but maintains a high degree of flexibility. It will through-cure readily and develop good bonding properties at elevated temperatures. No catalyst is necessary.—*General Electric Co., Chemical Dept., Pittsfield, Mass.*

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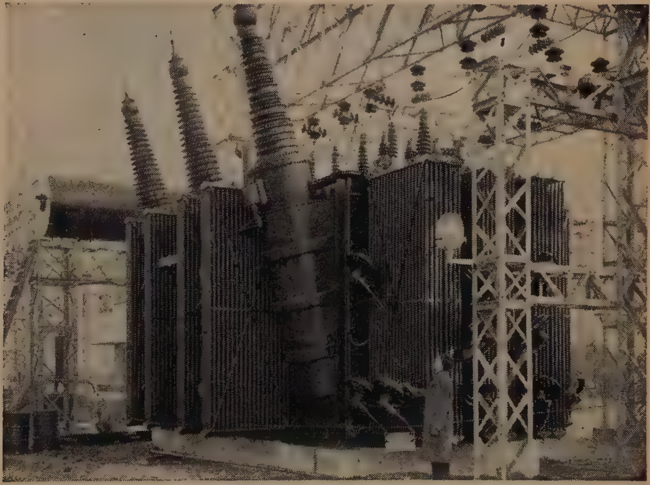

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Is it because of diesel power? Partly—though the Olympian Hiawatha between Chicago and the Pacific Northwest is pulled through the mountains by electric locomotives. Actually, many factors are involved including the skill of the engineer. Important, too, are the seasoned roadbed, heavy rail, expert maintenance and advanced car design which also contribute to the cushioned, silent ride.

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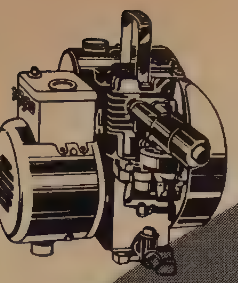
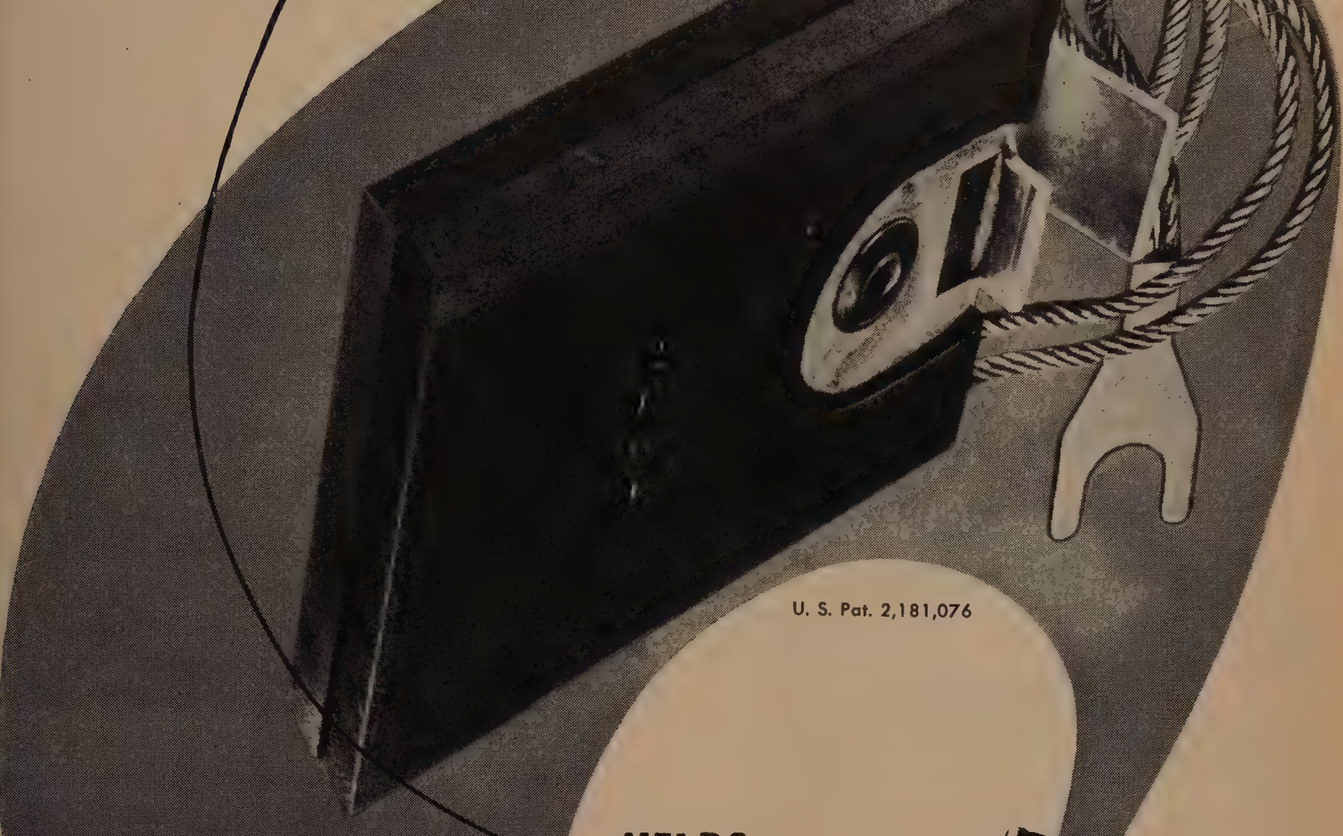
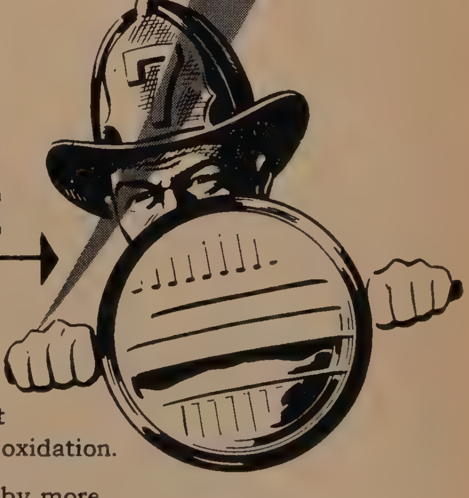




HELPS MAINTAIN MAXIMUM LIGHT HERE



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TRADE LITERATURE

Nickel Resistance—The resistance of nickel and its alloys to corrosion by caustic alkalies is the subject of this new technical bulletin. Effects of concentrations are given for nickel alloy irons, as well as for the higher nonferrous nickel alloys and pure nickel. Methods of testing are described and results given. Performances of the materials are analyzed in a variety of industrial applications which include soda manufacture; petroleum refining; transportation; and the production of such products as viscose rayon, soap, and pulp and paper. Numerous illustrations and tables supplement the text. Twenty-four pages. Technical Bulletin T-6.—*International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.*

Extrusion Presses—A bulletin illustrating and describing the latest equipment for four distinct fields of extrusion. These presses are for extruding metals such as aluminum, copper, and new alloys; lead pipe, fittings, strip, and solder; lead encasing for hose and electric cable; and carbon. Eight pages.—*Lake Erie Engineering Corp., Woodward Ave., Buffalo 17, N. Y.*

Compressors—Briefly presents a new line of JVG gas-engine-driven compressors available in three sizes—110-, 165-, and 220-hp. Details pertaining to the construction features are given, as well as a cross-sectional view and a list of uses to which the compressor is particularly adapted. Four pages. Form 3127-A.—*Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y.*

Insulation Tester—The complete line of Hypot Junior high-potential insulation-breakdown testing instruments is described together with details of simplified 3-step operation and its usage in testing leakage, breakdown, and short circuits. Four pages. Bulletin 4-A.—*Associated Research, Inc., 3755 W. Belmont Ave., Chicago 18, Ill.*

Capacitor—Describes the Auto-switch capacitor, completely metal-enclosed self-contained equipment that automatically switches 180 kvar of capacitance in response to circuit requirements. Explained are the numerous special features that contribute to safety, accessibility, and ease of installation. Dimensions, ratings, and data are included. Eight pages. GEA-4405-A. —*General Electric Co., Apparatus Dept., Schenectady 5, N. Y.*

Tiering Truck—Three designs of the new riding-type Space-Maker electric tiering truck are fully described in a two-color bulletin. Action photographs illustrate the space-saving feature, and many applications are suggested. Four pages. Bulletin No. 701.—*Lyon-Raymond Corp., 15171 Madison St., Greene, N. Y.*

Volt-ammeters—Describes the new Amprobe A-5-1 volt-ammeter, the third model to be added to a series of extremely small pocket-sized instruments. Thumb-nail sketches, together with brief descriptions, point up each of its many advantageous features. Four pages. Catalog No. 109-D.—*Pyramid Instrument Co., 49 Howard St., New York 13, N. Y.*

Relays—A presentation of Type AC-1 automatic reclosing relays for automatically reclosing electrically operated power circuit breakers. The descriptive text and illustrative material covers the advantages, rating, application, construction, burdens, operation, internal connections, and dimensions. Eight pages. GEA-1540D.—*General Electric Co., Apparatus Dept., Schenectady 5, N. Y.*

Notching Units—Mainly a pictorial presentation of a complete line of notching units including standard and semi-standard corner and edge-notching equipment. Also describes their interchangeable use and reuse in unlimited setups in stamping presses and press brakes. Twenty pages. Catalog N.—*Wales-Strippit Corp., 345 Payne Ave., North Tonawanda, N. Y.*

(Continued on following page)

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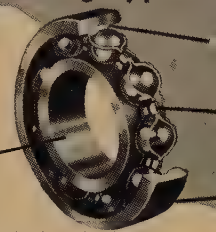

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TRADE LITERATURE (Continued)

Magnetic Controls—Completely describes and illustrates a line of magnetic starters; contactors; 4-, 6-, and 9-pole relays; and related accessories. Contents are conveniently indexed on the back cover. Sixteen pages. Catalog 50.—*Furnas Electric Co., Batavia, Illinois.*

Grinder-Miller—A new Super 50 grinder-miller together with a complete line of mounts for use in standard machine tools are illustrated and described in this catalog and price list. Application photographs depict the versatility and simplicity of operating this equipment. Eight pages; Catalog FG8. Eight pages; Price List FFG1.—*Precise Products Co., Racine 8, Wisconsin.*

Temperature and Pressure Instruments—A catalog presenting new measuring, exhibiting, and controlling temperature and pressure instruments. Cascade control systems also are described, as well as the Type 3 Pneumatrol pneumatic control unit. Twelve pages. Catalog 86.—*Fischer & Porter Co., Hatboro, Pa.*

Discharge Counter—Explains the function of the discharge counter for use with lightning arresters, touching on the principle of operation, design and construction, and installation. Several diagrams are shown. Four pages. GEA-3864-B.—*General Electric Co., Apparatus Dept., Schenectady 5, N. Y.*

Potheads—A complete listing of Type ST-Sodertite gasketless potheads. The bulletin also contains information on the use and construction of stress-relief cones and an outline of the G & W process for soldering metal to porcelain, as well as electrical and mechanical specifications for 5- to 69-kv single and multiple conductor units. Twenty pages. Bulletin AA50.—*G & W Electric Specialty Co., 7780 Dante Ave., Chicago 19, Illinois.*

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the *right* relay will improve

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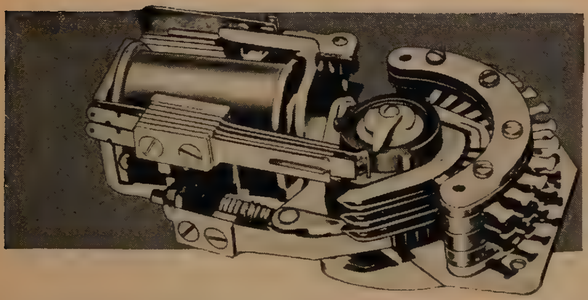
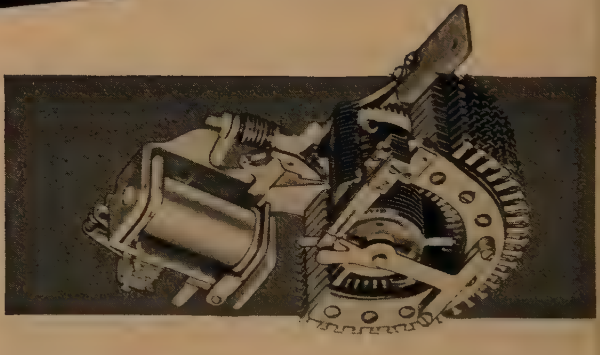
Automatic Electric relays and stepping switches are RIGHT on all counts! A wide range of standard types (including hermetically sealed relays, low-capacitance relays and the most compact stepping switch on the market!) permits your engineers to select and specify exactly the units they need. Assembled and adjusted to your exact specifications, they'll be shipped on schedule, ready to assemble into your production. And once in service, they'll go far to give your product a reputation for dependable, trouble-free operation.

For any product—for any purpose involving the use of relays or stepping switches—there is an Automatic Electric unit that's exactly RIGHT. We'll be glad to help you find it.

switches



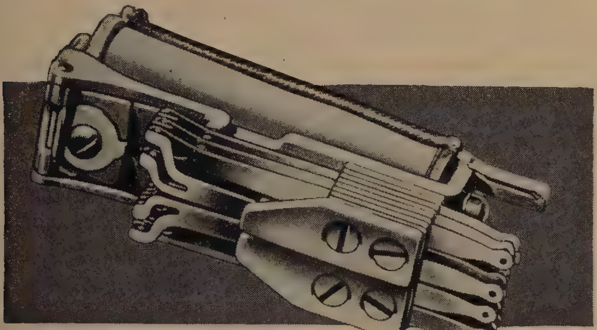
The Type 44 Miniature Stepping Switch You'll be amazed at this spring-driven d-c switch—it's so tiny and so light in weight. Yet it accommodates up to 6 bank levels, each with 10 points plus "home", and is adaptable to 10-, 20- or 30-point selection. Operation can be impulse-controlled or self-interrupted (using interrupter springs). Furnished with off-normal springs for mechanical "homing" (springs can also control auxiliary circuits). On 48 volts d-c, this switch runs 80 steps a second self-interrupted, 35 steps or more a second impulse-controlled. In rigid tests it averaged 200,000,000 steps—then required only minor readjustment.



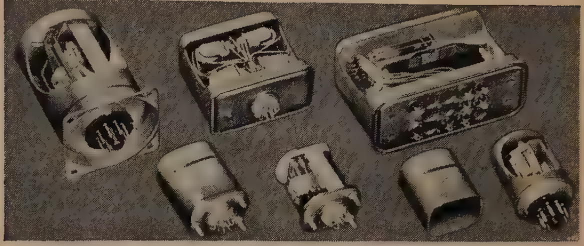
The Type 45 Stepping Switch This spring-driven switch is available both for d-c operation and with built-in rectifier for a-c operation. Accommodates up to 10 or more bank levels, each with 25 points plus "home", and is adaptable to 25- or 50-point selection. Provides for impulse-controlled or self-interrupted operation (using interrupter springs). Can be supplied with off-normal springs for mechanical "homing" (springs can also control auxiliary circuits). Runs 75 steps a second self-interrupted, and 35 steps a second impulse-controlled, on 48 volts d-c or 115 volts a-c. Has long service life, too—averaged 250,000,000 steps in rigid tests—then required only minor readjustment.

Wherever a relay or stepping switch is used in your product, it is likely to be important far beyond its cost. In fact, the performance of these components usually sets the standard of performance of the entire assembly. Thus, the use of the RIGHT relay or switch is often the simplest, most inexpensive way to make a good product better!

your product

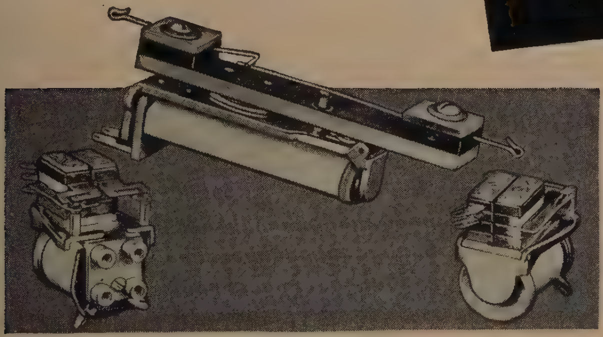


Class "B" Relays Types for extremely high speed operation and for time delays on either the operate or release strokes are available for d-c service; others for a-c operation. Independently operating "twin" contacts assure perfect contact operation. Contact points are dome-shaped to maintain uniformly low contact resistance. May be arranged in one or two pile-ups with maximum of 13 springs in each pile-up.



Hermetically Sealed Relays All Automatic Electric relays can be obtained in hermetically sealed housings. The "sealed-in" controlled atmosphere protects them from electrical or mechanical failure resulting from varying conditions of temperature, dust, humidity, acid, fungus or air pressure—and makes them completely tamper-proof.

relays



Low-Capacitance Relays For chatter-free control of high-frequency circuits. Two types, each providing exceptionally low capacitance between contact springs and between springs and ground. Equipped with "twin" contacts. Unusually small in size for compact mounting. The Class "C" relay shown above is especially suitable for strip mounting; it is only 0.687″ wide and 2⅛″ high and is 5-15/32″ in over-all length. The Class "S" relay (above foreground) is 1″ wide, 1-1/38″ high and 1-19/32″ over-all.

Write for our new 88-page catalog No. 4071F which gives complete specifications, performance and mounting data on the many types of relays and stepping switches manufactured by Automatic Electric Company, makers of telephone, signaling, communications and industrial electrical control apparatus. Address: AUTOMATIC ELECTRIC SALES CORPORATION, 1033 West Van Buren Street, Chicago 7, Ill. In Canada: Automatic Electric (Canada) Ltd., Toronto. *Offices in Principal Cities.*

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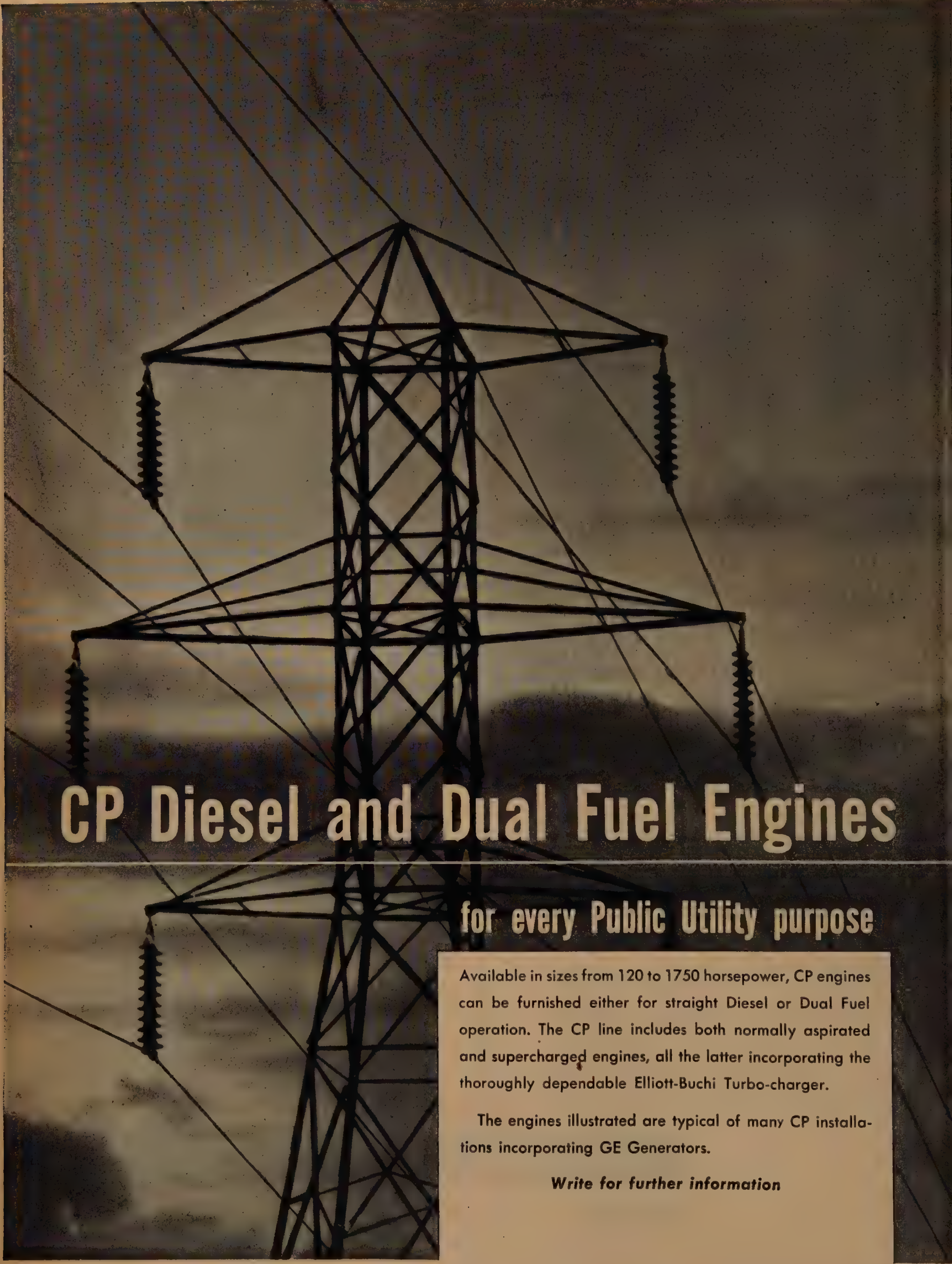

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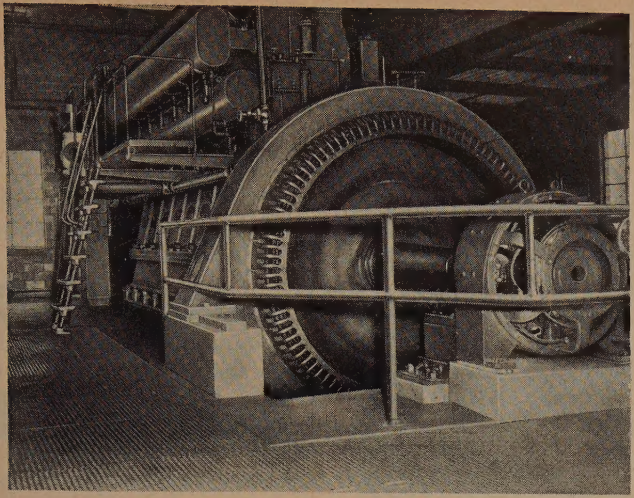
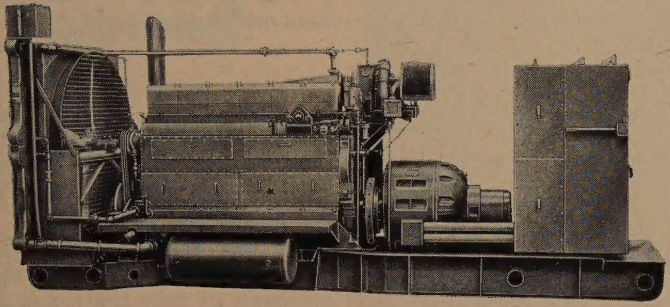
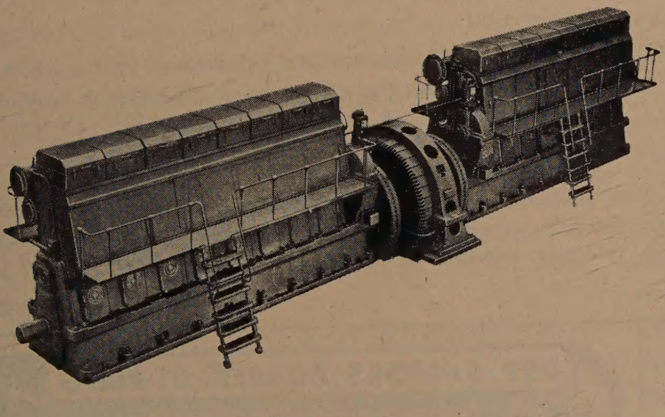


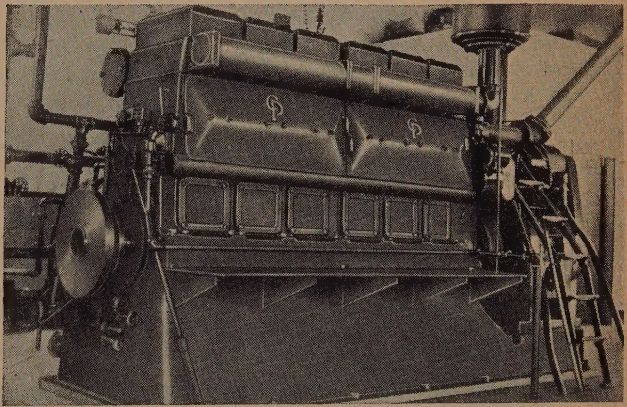
1650-hp Dual Fuel Generator unit in public utility plant – 327 rpm, 1150 kw.



500-kw CP Portable Generator unit for public utility emergency service.



Twin Engine Generator unit rated 2250 hp, 1500 kw.



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BOOK REVIEWS

(Available books may be purchased through the GENERAL ELECTRIC REVIEW *for domestic delivery; none sent on approval.)*

OUT OF MY LATER YEARS

Albert Einstein—Philosophical Library, New York. 1950. 282 pp. $4.75.

This is a collection of the comments of a great scientist and thinker on contemporary problems dating from just before the second World War. It includes a chapter on physical science dealing with the theory of relativity and the equivalence of mass and energy in a somewhat popularized form, and some discussion of a general field theory for all physics.

While it is understood that these scientific problems have been occupying most of Einstein's time during the last few years, the book is interesting to the general public mainly for his comments on problems of a political, economic, and sociological nature, including socialism and world federalism. The author admits to not being an expert on economic and social issues, but the reader will find a rare logic in his political orientation, which is of the European school that contributed Steinmetz and Thomas Mann to the American scene. In a world where political opinions are usually expressed by people of definite economic interests, it is refreshing to follow thoughts based on ethics alone.

Einstein defines science as "the endeavor to bring together by means of systematic thought the perceptible phenomena of this world into as thoroughgoing an association as possible." His book represents the application of systematic thought by a deeply religious scientist to the human problems in which all of us are or ought to be interested.

H. H. ZIELINSKI

SALES ENGINEERING (2nd Edition)

Bernard Lester—John Wiley & Sons, Inc., New York (Chapman & Hall, Ltd., London) 1950. 226 pp. $3.00.

Covering the field of selling productive equipment to industry, this book is particularly concerned with sales which involve the use of engineering knowledge and skill on the part of the salesman. The activities and attributes leading to successful results in this type of selling are thoroughly described. The author distinguishes sales engineering, which emphasizes performance results, from promotional selling, which emphasizes appeals to the buyers' emotions. He analyzes human considerations involved in sales engineering, but does not attempt to cover merchandising techniques for highly standardized products. Many illustrative anecdotes are included.

The second edition is similar to the first, but includes expanded treatment of some topics. An index has been added.

W. K. BOICE

THE PROTECTION OF TRANSMISSION SYSTEMS AGAINST LIGHTNING

Walter W. Lewis—John Wiley & Sons, Inc., New York (Chapman & Hall, Ltd., London). 1950. xiii+418 pp. $8.00.

This book presents concisely the principles, methods, and steps to be taken to protect electric power systems and equipment from damage or service interruption due to lightning.

The author, having made the study of lightning his major interest for the past quarter of a century, has been closely associated with all the successive developments of theories, measuring devices, field tests, laboratory experiments, and design practices that have now given us electric power systems practically immune from lightning damage.

In the course of his experience, Professor Lewis has published over sixty technical papers in this general field. The present book tells a fascinating story of the pioneering days. It also gives a clear understanding of the lightning art. And, finally, it is a practical guide for system design purposes.

P. L. ALGER

THE ELECTRIC POWER INDUSTRY: PAST, PRESENT AND FUTURE

Compiled by the Editorial Staff of *Electrical World*—McGraw-Hill Book Co., Inc., New York (Toronto, London). 1949. 178 pp. $3.50.

The authors and editors have used very good judgment in selecting this material, which is very comprehensive in scope.

Most of the writers are specialists in their fields, and all of them write with full knowledge of the various practices. They cover their subjects briefly but adequately.

This should be a valuable reference for those engaged in engineering for electric light and power systems. However, a systematic or classified index would have greatly increased its value from that point of view.

D. K. BLAKE

HYDROELECTRIC HANDBOOK (2nd Edition)

Wm. P. Creager and Joel D. Justin—John Wiley & Sons, Inc., New York (Chapman & Hall, Ltd., London). 1950. xxxii+1151 pp. $12.50.

Evaluation of a proposed site, design of the dam, selection of generating equipment, and duties of operating personnel are just a few of the varied aspects of the subject treated in this useful reference volume. In each chapter, the authors' method is to

(Continued on next left-hand page)

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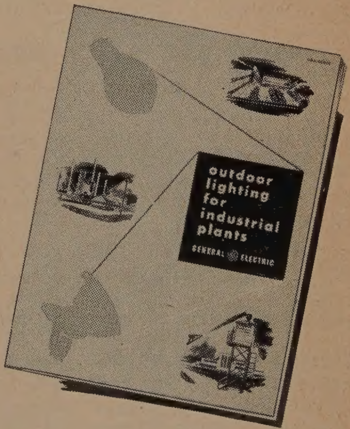

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D. E. Brainard

Heat Pump Applications

Emory N. Kemler and Sabert Oglesby, Jr.—McGraw-Hill Book Co., Inc., New York. 1950. 308 pp. $6.00.

This is a summary of the extensive heat-pump literature that has developed in the past few years. There are descriptions of a variety of industrial and commercial installations as well as of package units that have been marketed for residential use. The fundamentals of the cycle are covered; then follows a lengthy treatment of heat sources, particularly ground heat. Chapters on the components of a refrigerating system and storage arrangements are included, and the book ends with a brief description of several relevant patents.

The book does a good job of covering the matters the authors have chosen to treat. However, one could have wished for more emphasis on subjects peculiar to heat pumps, such as balancing heat and cooling requirements, switch-over problems, and further weather data. This could well be done at the expense of several items that are common to air conditioning and refrigeration and that have been treated in other texts.

W. R. Foote

Direct Current Motor Manual

H. S. Dusenbery—The Macmillan Co., New York (London, Toronto). 1950. 275 pp. $3.50.

This is a practical reference manual on d-c machines, written for the layman in a clear, easy style and presenting a general discourse on motor construction, operation, and servicing.

Extensive charts, wiring diagrams, and illustrations are provided for use in selection, installation, maintenance, and troubleshooting. There are also some interesting circuits, and comments on electronic speed controls, regulators, exciters, electronic rectifiers, control maintenance, and mechanical drives. A handy text for the practical technician.

Arnold H. Hoffer

Electron Microscopy

Ralph W. G. Wyckoff—Interscience Publishers, Inc., New York (London). 1949. 248 pp. $5.00.

The author presents a comprehensive and authoritative treatment for those intimately associated with electron microscopy, particularly as applied to biology and bacteriology. The book should also prove to be a good reference for those working in the general field of electron microscopy.

The introduction describes briefly the capabilities of microscopes using electrons for illumination. A chapter on the theory of the instrument, with a description of those in use in different parts of the scientific world, is followed by a rather detailed but very useful account of suggested adjustments for optimum performance of an electron microscope.

Since in electron microscopy the preparation of the specimen is equally as important as the operation of the instrument, the author has very wisely dealt at length with the various methods of specimen preparation.

The remainder of the book (approximately half) is devoted to scientific studies using the electron microscope—preponderantly in the fields of biology and bacteriology, with some emphasis on the studies of large molecules.

Well illustrated throughout, and with an excellent bibliography at the end of each chapter, the book is a worthy contribution to the science of electron microscopy.

J. G. Hutton